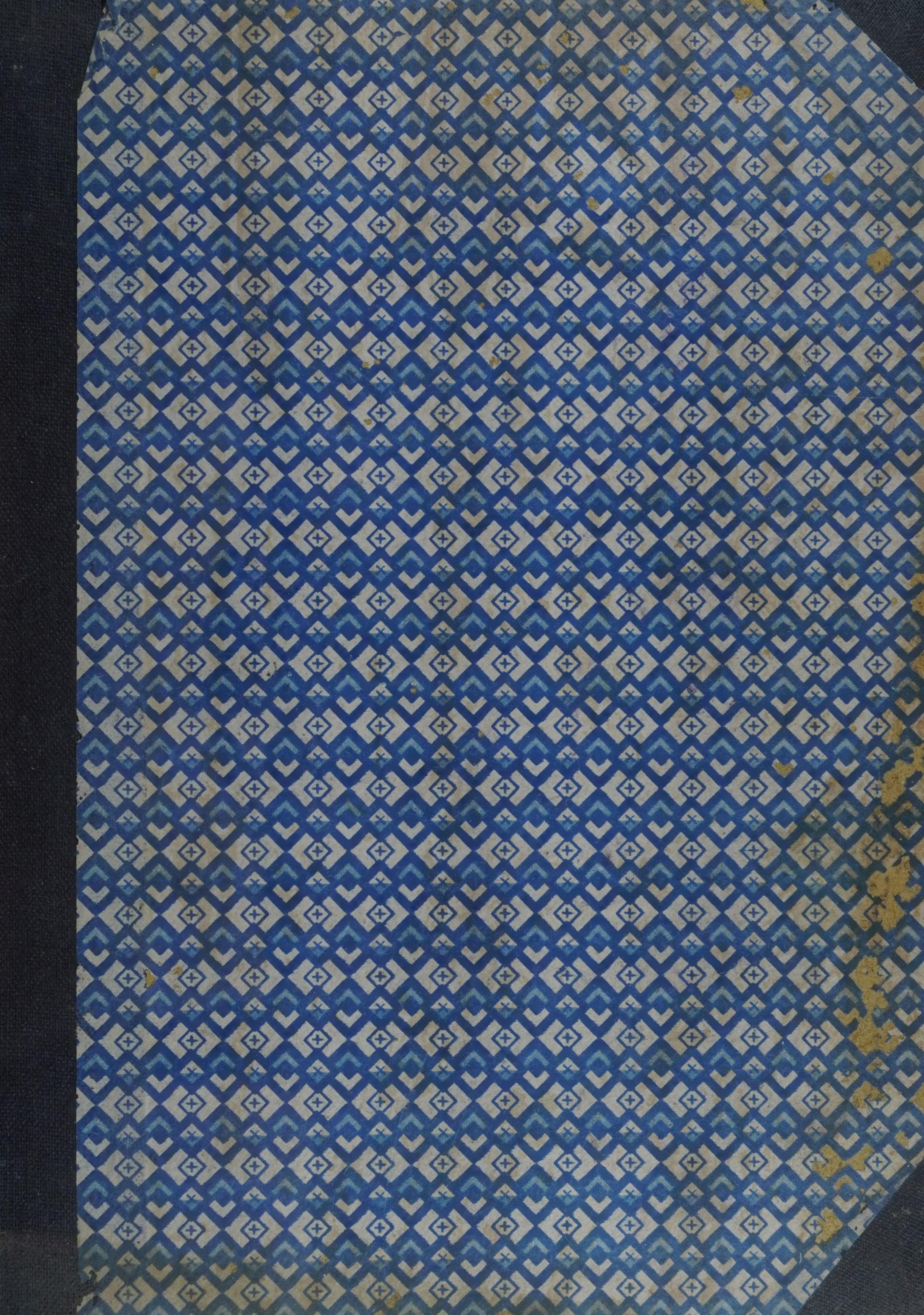

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ASSET 3/1

Abstracts of Selected Solar Energy Technology

Volume 3, Number 1, January 1981

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27 APR 198
C.F.T.R.I. MYSORE

太阳能 SOLAR ENERGY СОЛНЕЧНАЯ ЭНЕРГИЯ सौर ऊर्जा ENERGÍA SOLAR সৌর শক্তি
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OFFICIAL NEWSLETTER OF THE UNITED NATIONS CONFERENCE
ON NEW AND RENEWABLE SOURCES OF ENERGY

THE UNITED NATIONS UNIVERSITY

UNITED NATIONS CONFERENCE ON
NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

Unless otherwise explicitly stated, the views expressed in the abstracts and articles contained herein are not necessarily those of the United Nations University.

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Recipients are encouraged to provide **ASSET** with copies of their publications concerning the technological and socio-economic aspects of solar, bioconversion and wind energy utilization for abstracting in future issues.

THE UNITED NATIONS UNIVERSITY
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INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy
  B1 Radiation Measurement
  B2 Photovoltaic Conversion
  B3 Active Thermal Systems
  B4 Passive Thermal Systems

C. Bioconversion Energy
  C1 Biomass Production and Conversion
  C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

001/81 A THREE YEAR REVIEW. Photosynthesis & Energy Division (Shri AMM Murugappa Chettiar Research Centre, Madras (India)). Technical Notes No. 6 (June 1980). Shri AMM Murugappa Chettiar Research Centre, Tharamani, Madras 600042, India. 44p.

This report covers the work carried out at the Shri AMM Murugappa Chettiar Research Centre, Madras, India, from June 1977. The Centre's focus is on the application of science and technology to solving problems of the rural and urban poor, particularly through research and development work carried out in the areas of renewable energy, ecological- and economic-agricultural practices for nutritional and energy self-reliance, appropriate technology, health care, social-service systems and developmental communications. The Centre's basic policy is outlined and internally and externally funded projects are listed. A list is included of the 47 publications produced since 1977. The research and development activities include various biotechnology systems: algal systems, microbial systems, water hyacinth utilization systems, pisciculture biogas systems; food, fodder and forestry systems (including algal systems), cattle feeding with water hyacinth, biodynamic-intensive vegetable gardening, hydroponic raft culture in stagnant water, small-lot energy-food forestry, and energy plantations; wind and solar energy systems including a bidirectional horizontal-axis sail-wing windmill, a horizontal-axis down-wind sail-wing windmill, solar crop and fish dryers, solar cookers and water sterilizers; appropriate-construction systems including pond-construction systems, passive solar-building techniques and pond roofing; and communication systems.

002/81 ENERGY RESOURCES IN THE CDCC MEMBER COUNTRIES. Caribbean Development and Cooperation Committee (Office for the Caribbean, Caribbean Development and Cooperation Committee, Port of Spain (Trinidad)). E/CEPAL/CDCC/65 (28 May 1980). Office for the Caribbean, Economic Commission for Latin America, Port of Spain, Trinidad. 67p.

This paper is a background document describing the energy resources of the Caribbean nations. Under the heading of conventional-energy resources, petroleum, natural gas, coal, hydropower, thermal electricity, and fuel-wood and charcoal resources are considered. Non-conventional energy resources of 5 types are examined: solar, geothermal, nuclear, wind, and biological. 30 refs.

003/81 RENEWABLE BIO-SOLAR AND MICROBIAL SYSTEMS IN 'ECO-RURAL' DEVELOPMENT. E.J. DaSilva (UNESCO, 75700 Paris (France)), W. Shearer and B. Châtel. Impact of Science on Society, vol. 30, p. 225-34 (1980).

This article describes the possibilities available for development in rural areas based on adequate and reliable sources of energy that can be easily generated at low costs and are decentralized. Renewable-energy technologies and tasks in rural areas requiring energy are considered in detail. The potential and end-uses of organic residues are also considered for the production of food, feed, fertilizer, energy, chemicals and materials. Plants are seen as vectors for solar energy utilization in this context. Earthworms and fungus as well as other biological resources are considered. The distribution of representative solar and bio-energy programmes in rural Africa are presented, as well as the potential of biogas as a fuel in rural areas in some Latin American countries. A final section draws attention to the environmental impact of the utilization of biomass resources for eco-rural development. 25 refs.

B. SOLAR ENERGY

004/81 SOLAR ENERGY FOR RURAL DEVELOPMENT IN THE ASIA AND PACIFIC REGION. J.D. Walton, Jr. (Engineering Experiment Station, Georgia Institute of Technology, Atlanta, GA 30332 (USA)). Paper presented at the Symposium on Solar Science and Technology (held Bangkok, Thailand, 25 Nov.-4 Dec. 1980).

Solar energy technologies for developing countries are discussed as related to the energy needs of small farmers and rural communities in the Asia and Pacific region. The solar technologies considered are those developed for: (1) agricultural drying, (2) space heating, (3) cooking, (4) water pumping, (5) refrigeration, (6) small-scale electric power, (7) water heating, (8) desalination, and (9) production of fuel from biomass. The background and experience at the Georgia Institute of Technology in each of these technologies is described. Particular attention is given to those solar devices (typically solar thermal) which have the greatest potential for in-country manufacture using locally available materials and labour.

Both solar-thermal and photovoltaic systems are considered for providing electric power for water pumping, refrigeration and other small-scale electrical needs. Steam power is proposed as an appropriate energy system on which to build a mechanical- and electrical-power base. A hybrid steam system using concentrated solar energy and biomass waste is suggested as an attractive system for development in remote areas where these resources are readily available. It is concluded that the development of prototype hardware should be a cooperative effort between the technologist and the user or other appropriate people in the country or area of use, and that the primary role of the participating technologist from an industrialized country is to provide technical support or stimulus for such a cooperative effort rather than to independently attempt to develop "appropriate" technology for export to developing countries.

005/81 SOLAR ENERGY RESEARCH AND APPLICATIONS IN CHINA. Lu Wei De (Beijing Solar Energy Research Institute, Beijing (China)). Sun at Work in Britain, No. 10, p. 27-9 (1980).

China, with an area of 9.6 million km^2, receives an annual insolation equivalent to the energy produced by 1,200 billion tonnes of coal (2,000 times present production). From the study of solar cookers in the late 1950s China has been increasing its interest in solar energy. This article is a brief outline of the work that has been done and that is in progress including: collectors (30,000 m^2 in Beijing); selective coatings; dryers; cookers (box and concentration types); solar houses and office buildings; distillation; welding; and solar cells.

006/81 DESALINATION AND SOLAR ENERGY (DESSALEMENT ET ENERGIE SOLAIRE). R. Ployart (Centre d'Etudes Nucléaires de Saclay, Commissariat à l'Energie Atomique, Gif-sur-Yvette (France)) and A. Maurel. DGRST-77 7 1225 (1979). Délégation Générale à la Recherche Scientifique et Technique, Paris, France. 2 vols., 79p.

This document considers the optimization and operation of flat-plate energy-collecting units adapted to the classical processes of desalination and the coupling of solar energy systems to classical desalination units. Comparative estimates are made of the costs of desalted water obtained by solar distillation using the greenhouse effect, the combination of distillation with solar heating and the combination of a solar pump with an osmotic separator.

L'optimisation et la performance des unités solaires à capteurs plans actuellement adaptées aux procédés classiques de dessalement et le couplage de l'énergie solaire avec des appareils de dessalement classiques sont décrits dans ce document. Des estimations sont presentées des prix de revient de l'eau obtenue pour la distillation solaire du type serre, par couplage distillation-chauffage solaire, et par couplage pompe solaire-osmoseur.

007/81 STATUS AND PROSPECTS OF LOCAL SOLAR HEATING AND COOLING SYSTEMS. V.M. Puri (Kuwait Institute for Scientific Research, P.O. Box 12009 (Kuwait)). P. 769-74 of Renewable Energy Prospects (Proceedings of the Conference on Non-fossil Fuel and Non-nuclear Fuel Energy Strategies, held Honolulu, Hawaii, USA, 9-12 Jan. 1979). Pergamon Press, Oxford, UK (1980). US$50.00 for entire book [Reprinted in Energy, vol. 4, p. 769-74 (1979)].

In this paper a state-of-the-art of solar heating and cooling systems is presented. Solar air heaters and different types of solar water collectors are discussed in detail. Storage systems including water, rocks, and heat-of-fusion salts are described as are space-heating systems employing solar air heaters (in conjunction with rock or heat-of-fusion salt storage). The use of water collectors plus hot-water storage for space heating and domestic hot water is also outlined. An indication of the commercialization of various space-heating systems and broad economic projections are presented. The three major solar-cooling methods (absorption cooling, solar mechanical systems, and systems involving humidification-dehumidification cycles) are also discussed in detail. Finally, an overview of solar heating and cooling activities in Kuwait is given.

008/81 NONTRACKING CONCENTRATING SOLAR COLLECTOR. A.M. DeGeus, St. Petersburg, FL (USA). US Patent 4,222,370. File date: 17 May 1978.

This device is a non-tracking concentrating solar collector comprising a series of parallel parabolic-reflector segments which are reflective on both surfaces and which have focal points lying in a plane which is approximately at a right angle to the direction of incident solar radiation. The incident radiation is received in the space between the upper ends of the reflector segments, the lengths of which are selected so that the incident radiation is reflected back and forth between the segments until the fourth and sixth reflections emerge downwardly from between the reflector segments in a beam which is much narrower than the space between the upper ends of the reflector segments. At least one collector for solar radiation is positioned beneath the reflector segments, other than the first segment, and parallel to these segments so as to receive the narrowed beam.

009/81 SIMPLE SOLAR TRACKING SYSTEM. K.C. Gupta, R.K. Mirakhur and A.P. Sathe (Birla Institute of Technology and Science, Pilani (India)). Vol. 2, p. 1336-40 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon

Press, Elmsford, NY, USA (1978).

A falling weight, controlled by a pendulum, drives a shaft which is parallel to the axis of the earth at a rate of one revolution per day. The concentrator (convex lens) is mounted on the shaft and tracks the sun. Changes in the declination of the sun are accounted for correctly when the device is adjusted manually to point towards the sun each morning. A method is presented for correctly aligning the rotating shaft parallel to the axis of the earth by making observations of the focal spot of the sun. 3 refs.

010/81 LOW COST, DURABLE ANTI-REFLECTIVE FILM FOR SOLAR COLLECTORS. E.M. Pastirik and M.C. Keeling (Motorola Inc., Phoenix, AZ (USA)). P. 620-3 of Proceedings of the IEEE Photovoltaic Specialists Conference (held Washington, DC, USA, 5 June 1978). Institute of Electrical and Electronics Engineers, New York, NY, USA (1978)

The physics of reflection reduction by thin films is briefly reviewed. Current techniques for the production of anti-reflective coatings are surveyed with respect to their applicabilities to solar-panel covers. Techniques for the production of suitable anti-reflection coatings based on acid-hardened sodium-silicate solutions are presented along with optical data for both acid-leached and silicate coatings.

011/81 PHOTOCHEMICAL ENERGY CONVERSION STUDIES IN SYSTEMS CONTAINING METHYLENE BLUE. A.S.N. Murthy and K.S. Reddy (Indian Institute of Technology, New Delhi 110029 (India)). International Journal of Energy Research, vol. 3, p. 205-10 (1979).

This article reports the result of an experimental study involving an examination of the behaviour of photo-electrochemical cells containing methylene blue and different reducing agents. 20 refs.

012/81 SOLAR ENERGY COLLECTING POND. UOP Inc. US Patent 4,110,172 (29 Aug. 1978) 8p.

A water-containing pond is disclosed for collecting solar energy for utilization in a process for recovering potable water from non-potable water and/or for the generation of power. The solar pond is designed to increase the quantity and efficiency of water evaporation, from heated pond water, into a heated flowing-air stream. Construction is such that there is afforded an increase in the absorptivity/emissivity (α/ε) ratio with respect to the incidence of solar radiation.

013/81 PHOTOELECTRIC CONVERTERS OF CONCENTRATED SOLAR RADIATION UTILIZING AlGaAs HETERO-STRUCTURES. Z.I. Alferov, V.M. Andreev, Y.M. Zadiranov, V.I. Korol'kov, T.S. Tabarov and F.M. Tadzhibaev (A.F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad, (USSR)). Soviet Physics-Semiconductors, vol. 13, p. 298-301 (Mar. 1979).

The optimal structure of hetero-junction cells for conversion of concentrated solar radiation was selected by investigating three types of cell structures based on abrupt and linear-gradient GaAs-AlAs hetero-structures at a wide range of radiation intensities. A study was made of the spectral characteristics for various degrees of concentration of solar radiation. At high radiation intensities the quantum efficiency increased in the short-wavelength-sensitivity region due to the photon mechanism of non-equilibrium carrier transport. The constructed solar cells had an efficiency of 18.5% when solar radiation was concentrated by a factor $K_c \approx 1000$ (for an air mass $m = 1.25$) and 16.5% for $K_c \approx 2500$. A study was made of the ways of increasing further the efficiency of cells operating at high radiation intensities.

014/81 CdS-CdTe SOLAR CELL PREPARED BY VAPOR PHASE EPITAXY. K. Yamaguchi, N. Nakayama, H. Matsumoto and S. Ikegami (Matsushita Electrical Industry Co., Osaka (Japan)). Japanese Journal of Applied Physics, vol. 16, p. 1203-11 (July 1977).

CdS-CdTe solar cells were prepared by epitaxial growth of CdS on p*CdTe wafers, and the properties of the cells were extensively studied. The cells have a junction structure of n*CdS-(n or i)*CdTe-p*CdTe. Formation of the (n or i) layer is due to diffusion of In into CdTe; the thickness of the layer was 0.5 µm in the most efficient cell. The best cell exhibited a solar conversion efficiency of 10.5% under illumination by sunlight (AM1.3, 68 mW/cm^2), and 6.0% under illumination by simulated sunlight (AM0). The high efficiency is attributed to the reduction in both the series resistance and surface recombination, which results from the presence of the heavily doped CdS layer on the wafer. The cell is not humidity sensitive and is stable in the forward-bias test. These results suggest strongly that practically useful solar cells can be manufactured from this type of junction. 25 refs.

015/81 PHOTOVOLTAIC CHARACTERISTICS OF CHEMICALLY DEPOSITED PHOTOSENSITIVE CELLS. P. Sen, P. Mahanty and H. Misra (Ravenshaw College, Cuttack (India)). Indian Journal of Pure Applied Physics, vol. 16, p. 642-5 (July 1978).

Chemically deposited thin films of $CuCl_2$ on brass, $ZnCl_2$ on zinc and $AlCl_3$ on aluminium were found to exhibit photovoltaic properties, with a definite lifetime varying from sample to sample. The amount of photovoltage developed was found to depend on the (1) composition of the thin film (and not on the size of the thin film), (2) dipping time into the chemicals during the preparation of the film, (3) contact area of the film, (4) the time of exposure of the film to the light source, and (5) wavelength of the illuminating radiation.

016/81 RESEARCH IN PHOTOVOLTAIC CELLS. S. Vojdani (Materials and Energy Research Centre, Tehran (Iran)). P. 21-34 of Soltech '78 (Proceedings of the Middle East Solar Technology Exhibition and Conference, held Manama, Bahrain, 24 Apr. 1978). UK Section of the International Solar Energy Society, London, UK (1978).

Short-, mid- and long-term applications of photovoltaic power supplies, especially in developing countries and remote areas, are discussed. The dominant technologies in solar-cell materials and fabrication are reviewed including mono-crystalline, ribbon sheet, and poly-crystalline silicon solar cells(with and without concentration)and CdS solar cells.

017/81 HIGH EFFICIENCY, HIGH DENSITY TERRESTRIAL SOLAR PANELS. M. Wihl and J. Wohlgemuth (Solarex Corp., Rockville, MD (USA)). P. 155-9 of Proceedings of the IEEE Photovoltaic Specialists Conference (held Washington, DC, USA, 5 June 1978). Institute of Electrical and Electronics Engineers, New York, NY, USA (1978).

The prevailing terrestrial solar-array technology employs round silicon solar cells that exhibit poor packing density and have total-area efficiencies of 6 or 7%. By using rectangular or nearly rectangular cells the packing density can be appreciably increased and total panel efficiencies of 13% are possible. The technology has been developed to fabricate large-area square, rectangular, and nearly rectangular cells with 14 to 15% conversion efficiencies at 1 kW/m^2 at 28 °C. When these cells are used in terrestrial panels, packing densities in excess of 90% have been achieved. Panels have been fabricated that exhibit 13% total panel-area efficiency. Economic evaluations have been made for the different types panels using today's technology and projecting costs for future developments. These high-density panels set the stage for future developments in silicon technology when rectangular substrates become available.

018/81 POWERING A SUBMERGED PUMP WITH A PHOTOVOLTAIC GENERATOR USING A TRANSISTORIZED THREE-PHASE INVERTER (ALIMENTATION D'UNE POMPE IMMERGEE A PARTIR D'UN GENERATEUR PHOTOVOLTAIQUE A L'AIDE D'UN ONDULEUR TRIPHASE A TRANSISTOR). M. Barlaud, G. Sow and C. Masselot (Ecole Nationale Supérieure Universitaire de Technologie, Dakar-Fann (Senegal)). Revue de Physique Appliquée, vol. 15, p. 263-9 (1980).

A pumping system using an electronic three-phase chopper-inverter unit to power an asynchronous 2.2-kW motor and experimental results using this system are described. 6 refs.

Description de l'installation de pompage utilisant un ensemble électronique hacheur-onduleur triphasé alimentant un moteur asynchrone de 2,2 kW et présentation des résultats expérimentaux de l'emploi de cette installation. 6 réf.

019/81 INTERNATIONAL PHOTOVOLTAIC PROGRAM PLAN. VOLUMES I AND II. D. Costello, R. Koontz, O. Posner, P. Heiferling (Solar Energy Research Institute, Golden, CO (USA)), P. Carpenter, S. Foreman and L. Perelman. SERI/TR-353-361 (Dec. 1979) 321p. NTIS.

This international photovoltaic programme involving the expenditure of approximately $135 million in US government funds is to accelerate the widespread use of photovoltaic systems in international markets. The major benefits of the programme are expected to be the maintenance, stabilization and fostering of the expansion of the photovoltaic industry both in the USA and abroad by facilitating world-wide sales and the economic, political and social advancement of the developing nations that utilize the technology. Other benefits are seen to be: reducing the rate of growth in the world-wide demand for oil; helping to improve the US balance of trade; and encouraging co-operation. Programme elements to implement the plan are: market demonstrations, systems development, supplier assistance, purchaser assistance and an information clearing house. Volume II is devoted to appendices including information: relevant US legislation and programmes; programmes and government actions considered in preparing the plan; photovoltaic technology; characterization and assessment of potential European and Japanese competition; industry perspectives on international markets; policy strategies for the international marketing of US photovoltaic products; impact of international financial institutions on markets; and photovoltaic cell issues in developing countries including commercialization priorities and transnational questions.

B3. Active Thermal Systems

020/81 COMPACT SHALLOW SOLAR POND HOT WATER HEATER. A.I. Kudish and D. Wolf (Ben Gurion University of the Negev, Beer-Sheva (Israel)). Solar Energy, vol. 21, no. 4, p. 317-22 (1978).

The concept of the shallow or convecting solar pond has been discussed in the literature in great detail but with regard to large-scale installations only. A prototype unit was constructed and tested. It consisted of a clear PVC pond placed within an insulated wooden container equipped with a hinged cover. The upper glazing was a 0.1 mm Tedlar film. The container cover served a dual purpose. During the day it performed as a solar reflector by means of an aluminized Mylar film affixed to the inner site, and it was thermally insulated so as to enable the overnight storage of the heated water. 3 refs.

L'idée des bassins solaires peu profonds convectifs a été discutée en grand détail, mais seulement concernant les grandes installations. Les auteurs ont construit et essayé un tel prototype. Il consiste en un bassin transparent de chlorure de polyvinyle installé dans une boîte isolée de bois, munie d'un couvercle à charnières. La partie supérieure consiste en une couche de Tedlar de 0.1 mm d'épaisseur. Le couvercle de la boîte a un double usage: pendant la journée il sert de réflecteur solaire par l'intermédiaire d'un film de Mylar aluminisé fixé à sa partie inférieure, et il est thermiquement isolé, permettant de conserver l'eau chauffée pendant la nuit. 3 réfs.

El concepto de piletas solares poco profundas o piletas solares convectivas ha sido estudiado en gran detalle, pero sólo respecto a instalaciones de grandes dimensiones. Los autores han construído y probado un prototipo de esas características. Consiste en una pileta de PVC transparente instalada dentro de una caja de madera aislada, equipada con una tapa abisagrada. La cara superior consiste en un film de Tedlar de 0.1 mm de espesor. La tapa de la caja sirve para un doble propósito. Durante el día actúa como reflector solar por medio de un film de Mylar aluminizado fijado en su cara interior, y está térmicamente aislada para permitir conservar el agua caliente durante la noche. 3 refs.

021/81 PIPE TYPE SOLAR WATER HEATING. S.K. Kaila, R. Ganguly, J.S. Puri and N.K.D. Choudhury (Central Building Research Institute, Roorkee (India)). Vol. 2, p. 598-602 of Proceedings of the International Conference on Solar Building Technology (held London, UK, 25 July 1977). C. Stambolis (ed.), RIBA Publications Ltd., London, UK (1978).

A pipe-type solar water heater consisting of eight pipes fabricated from galvanized-iron sheet has been designed and developed at the Central Building Research Institute, Roorkee, India. The pipes perform the dual function of absorbing heat and storing the heated water. It may be coupled to a separate storage tank which can be installed in a bathroom or kitchen. A prototype of the pipe-type solar water heater was tested under different operating conditions. The results show that the designed solar heater supplies 100 liters of water at a maximum temperature of 67 to 70 °C at 3:00 P.M. provided there were no withdrawals of hot water during the day. However, if 10 liters of hot water at hourly intervals are drawn for day-time use, starting from 9:00 A.M., then the maximum temperature of 10 liters of water drawn at 3:00 P.M. is 55 °C. 2 refs.

022/81 PRELIMINARY RESULTS FROM A TEST ARRAY OF 3X CPC COLLECTORS IN A SCHOOL HEATING APPLICATION. M. Collares-Pereira, J. O'Gallagher, A. Rabl, H. Simmons, C. Stein, L. Wharton, R. Winston and W. Zitek (University of Chicago, Chicago, IL (USA)). Vol. 2, p. 347-51 of Solar Diversification (Proceedings of the Meeting of the American Section of the International Solar Energy Society held Denver, CO, USA, 28 Aug. 1978). K.W. Böer and G.E. Franta (eds.), American Section of the International Solar Energy Society, Newark, DE, USA (1978).

An array of 56 double-trough compound-parabolic-concentrator (CPC) solar-collector modules has been installed on the roof of an elementary school on the Navajo Indian Reservation near Gallup, New Mexico, USA. The array represents an effective net collecting area of 72.9 m^2 and has been fully instrumented to provide a data base for analysing CPC collection characteristics. This is the first quantitative field test of these collectors conducted anywhere. The basic design is a 3X CPC matched to a finned tubular absorber with an acceptance half-angle of ±18°, allowing collection for half a year without adjustment. Very preliminary results from the late spring are reported.

023/81 SOLAR WATER HEATER WITH HEMICYLINDRICAL BOILER. O. Shadyev, Y.N. Yakobov and A.I. Imomkulov. Applied Solar Energy, vol. 14, no. 1, p. 63-4 (1978) [English translation of Гелиотехника, vol. 14, no. 1, p. 77-9 (1978)].

A solar water heater with a hemi-cylindrical boiler was proposed and studied experimentally. The experimental results are presented in the form of tables and figures.

024/81 SOLAR HOT WATER HEATER. J. Garlitz. Eastern Oregon Community Development Council, La Grande, OR, USA (May 1977) 69p.

Step-by-step instructions are supplied for constructing an inexpensive thermo-syphon solar domestic hot-water system. A list of materials and tools required for constructing the collector includes inexpensive alternatives which may be substituted for purchased materials, such as newspaper for fiberglass insulation. Complete component-construction directions and assembly guidelines are included. A water-filled 209-liter barrel is recommended as the heat exchanger and is fitted with two sets of copper-tube coils, one for the heated collector fluid and the other to transfer heat to a conventional hot-water heater. Materials and construction details are listed for fabricating an insulated-box structure to hold the heat exchanger with a lower support structure for emplacement of the collector. Diagrams are provided for installing the solar hot-water system and for connecting the system to existing plumbing. Start-up procedures, such as filling the system with an antifreeze solution, and maintenance instructions are included as well as appendices containing alternative system configurations and a master list of materials.

025/81 SINGLE ROOM HEATING BY SOLAR RADIATION. V.K. Gupta, H.R. Tyagi and N.K. Tiwari (J.N. Agricultural University, Jabalpur (India)). Vol. 3, p. 1629-30 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

A small solar heater, utilizing the stack effect, was fabricated to evaluate its efficiency in providing a comfortable temperature in an office room. The warm air, thus supplied, made the occupant quite comfortable during the working hours of winter days. 4 refs.

026/81 TURBINES AND TURBOGENERATORS FOR SOLAR POWER PLANTS WITH THERMODYNAMIC CYCLES. M.P. Pocard (Societé Rateau, La Courneuve (France)). P. 635-8 of Proceedings of the International Colloquium on Solar Electricity (held Toulouse, France, 1 Mar. 1976). In French.

Societé Rateau has developed a light turbogenerator which can be used over a power range from 20 to 200 kW for thermodynamic-cycle solar-power stations using small temperature differences. The first machine of this type, which uses freon as the working fluid and develops 30 kW, is now working in Mexico in an installation with plane collectors for water pumping. Other types of turbines and turbo-generators are being presently designed for use at higher power and/or frequencies. This paper describes the acquired experience, and gives the technical state-of-the-art in this field and its expected development.

027/81 HEATING OF BUILDING WITH SOLAR ENERGY. G.O.G. Löf (Colorado State University, Fort Collins, CO 80523 (USA)). Vol. 3, p. 1-12 of Sharing the Sun: Solar Technology in the Seventies. K.W. Böer (ed.), American Section of the International Solar Energy Society, Cape Canaveral, FL, USA (1976).

This review of the solar heating of buildings includes a brief description of the principal types of solar-heating systems, an indication of their degree of commercialization, and an evaluation of current and near-future economic factors. Attention is given to solar heating with liquid collectors and hot-water storage, solar heating with air collectors and pebble-bed storage, systems with a combined collector-storage unit, systems with high efficiency utilizing special design features, and solar-heating prospects and impacts. It is concluded that the solar-heating industry will experience an enormous growth during the next two decades.

028/81 ANALYSIS AND PERFORMANCE OF A SOUTH FACING SOLAR WALL. G.N. Tiwari, A. Srivastava and A. Kumar (Indian Institute of Technology, New Delhi (India)). P. 175-80 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

An analysis of the performance of a solar wall as a collector-storage system is given. The south-facing wall consists of a mass of concrete whose one surface is blackened-glazed and exposed to solar radiation while the other surface is in contact with room air at a constant temperature of 20 °C. A network of pipes (metallic or plastic) is laid in a plane from which heat can be extracted by fluid flow in such a manner that the temperature of the plane of heat retrieval remains constant. The collection efficiency of the system is found to be 80.0 and 60.7% for surface collection temperatures of 20 and 25 °C respectively.

029/81 A COMPARING ANALYSIS OF SIX GENERIC SOLAR DOMESTIC HOT WATER SYSTEMS. R. Famington, D. Norean and L.M. Murphy (Solar Energy Research Institute, Golden, CO (USA)). SERI/TP-351-549 (Jan. 1980) 6p. NTIS.

Results are analysed from experiments on six types of solar domestic hot-water systems at the US National Bureau of Standards. Use of pumps, fans, controls and solenoid valves in the pumping systems resulted in high parasitic energy consumption. Storage losses from double-tank systems were greater than expected due to poor storage-tank insulation. Direct systems performed better than indirect systems as expected. The thermosyphon system delivered the most solar energy to the hot-water load for lowest initial cost. The air system performed poorly due to the parasitic energy consumption and poor heat transfer across the air-to-water heat exchanger. Reliable freeze protection needs to be developed for direct systems, especially thermosyphon systems, to take advantage of direct heat transfer. 5 refs.

030/81 COST-EFFECTIVE SELECTION OF FLAT-PLATE SOLAR COLLECTORS. D.M. Deffenbaugh and H.J. Carper (Southwest Research Institute, San Antonio, TX (USA)). P. 619-33 of Proceedings of the 1977 Flat-Plate Solar Collector Conference (held Orlando, FL, USA, 28 Feb. 1977) (Sept.

1977). NTIS.

An experimental programme was conducted to determine the instantaneous thermal efficiencies of 16 different flat-plate solar-collector designs. These collectors featured selective and non-selective absorber-plate coatings, and single and double covers of water-white crystal glass, float glass, and fiberglass-reinforced plastic. An indicator based on initial collector cost and instantaneous thermal efficiency was devised to allow the selection of the most cost-effective collector. It is shown that the cost effectiveness varies with operating conditions, and that a single collector design is not necessarily the most cost effective for all operating conditions. All-day efficiency tests were conducted for several collector designs, and the results were used to predict the long-term thermal performance for all 16 collector designs. Two design examples are presented in which the initial cost of the collector bank for each of the 16 collector designs is calculated. It is shown that the savings realized by selecting the most cost-effective collector in comparison with the least cost-effective collector can be as high as 60%.

B4. Passive Thermal Systems

031/81 PERFORMANCE OF NATURAL ICE MAKERS. M.N. Bahadori and A. Kosari (Shiraz University, Shiraz (Iran)). Vol. 3, p. 1976-7 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

The performance of the natural ice makers (Yakh-chal) which provided ice for centuries in most Iranian cities was studied both experimentally and analytically. It was shown that on clear winter nights when the ambient air temperature was as high as 4 °C and when the wind velocity and the relative humidity ranged between 0-10 km/h and 30-60%, respectively, ice could be formed. Under such conditions the sky temperature was estimated to be about -30 °C. 2 refs.

032/81 EFFECT OF CLOSED FORCED CIRCULATION OF A STEAM-AIR MIXTURE IN A SOLAR DESALINATION UNIT. S. Seyitkurbanov and L.I. Rabinovich (Physicotechnical Institute, Ashkhabad, Turkmen SSR (USSR)). Гелиотехника, no. 2, p. 50-2 (1978). In Russian.

Experiments were done on closed forced circulation of a steam-air mixture under full-scale conditions in two sections of a solar-desalination facility on the solar-engineering test grounds of the Physicotechnical Institute of the Turkmen Academy of Sciences. A circulating blower in an enclosed housing was located over the centre of the evaporative surface. As the blower operated, a steam-air mixture was drawn from beneath into the housing and raised to the glassed-in surface and split into two flows, each going to its own end of the desalinating unit. The results of the experiments showed conclusively that forced circulation in an enclosed space increases the productivity of the desalination unit. Further experiments are needed to define more precisely the problems of optimization of the process, including determination of periodicity, intensity, and duration of the forced circulation.

033/81 EXPERIMENTAL STUDY INTO COOLING EFFECT BY NOCTURNAL RADIATION TO OUTER SPACE FOR POSSIBLE APPLICATIONS IN RURAL AREAS. A.K.M.A. Quader (Bangladesh University of Engineering and Technology, Dacca (Bangladesh)). P. 304-10 of Proceedings of National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

The cooling effect produced by nocturnal radiation to outer space may be used to obtain a cooled medium to be used as a refrigerant to create a cold space in a rural location where other conventional means of cooling are unavailable. An experimental investigation has been undertaken to study nocturnal radiation under local conditions. It has been possible to cool water below the minimum wet-bulb temperature of the night. The rate of cooling per m^2 of surface exposed to outer space lies in the range 37.6 to 95 W. More work is in progress on a refrigeration model which will use the cooling effect of nocturnal radiation to cool the refrigerant for the model.

034/81 DEVELOPMENT OF FLAT PLATE TYPE SOLAR ENERGY GRAIN DRYER. B.R. Birewar (Indian Grain Storage Institute, Hapur (India)). Bulletin of Grain Technology, vol. 16, p. 108-113 (1978).

A prototype grain dryer powered by a solar air heater is described. Test results and costs are presented.

035/81 PRELIMINARY STUDIES OF A LOW FUEL, HOP DRYING KILN FOR HIMACHAL PRADESH, INDIA. P.E. Doe, B.K. Bhat and R.C. Menary (Agricultural Department, University of Tasmania, Hobart, Tasmania 7001 (Australia)). Food Technology in Australia, vol. 31, p. 302-6 (1979).

Experiments on a prototype solar hop-drying kiln are described. A theoretical examination shows that using hop residues for burning in an ordinary dryer is economical. 4 refs.

036/81 GREENHOUSES ORIENTED TO THE SUN (FOR

MORE AND EARLY PRODUCTION). A. Vatansever (Findikzade, Sair M. Emin Sok, No. 417 Capa, Istanbul (Turkey)). Vol. 2, p. 745-54 of Proceedings of the International Conference on Solar Building Technology (held London, UK, 25 July 1977). C. Stambolis (ed.), RIBA Publications Ltd., London, UK (1978).

For the design of greenhouses in Istanbul, Turkey (41° N), a variation in the elevation of the sun from 50° at the Vernal Equinox to 72.5° in the summer and a crown inclination of 4.5° had to be taken into consideration. Some simple designs are discussed. 2 refs.

037/81 HEAT PIPES FOR SUN ENERGY CONVERSION. Z. Murgu, E. Tvardochlieb, D. Murgu, L. Cojocaru and M. Hazum (Centrul de Cercetari Tehnice şi Fizice Iaşi, Iaşi, (Romania)). P. 408-13 of Proceedings of the Third Heat Pipe Conference (held Palo Alto, CA, USA, 22 May 1978). American Institute of Aeronautics and Astronautics, Washington, DC, USA (1978).

The possible applications of heat pipes in the field of sun-energy conversion, such as collectors or energy conveyors, are given. Manufacturing and operation data of some heat pipes built for this purpose are shown. These are quarter-transfer or heat-exchanger tubes of $L = 0.5 - 1$ m and $D_e = 30\text{-}50$ mm. Their operation with several working fluids and suitable porous structures, working in the presence or absence of external forces, are discussed.

C. BIOCONVERSION ENERGY

038/81 FUEL FROM MICROALGAE. J.R. Benemann (University of California, Berkeley, CA (USA)). P. 53-8 of Proceedings of the Third Annual Biomass Energy Systems Conference (held Golden, CO, USA, 5 Jun. 1979). SERI/TP-33-285 (Oct. 1979). NTIS.

Two microalgal systems for the production of fuels were studied: methane fermentation of sewage-grown microalgal biomass and biophotolysis using blue-green algae. Although microalgal ponds have been used in waste-water treatment for several decades, the high cost of harvesting microalgae is limiting the applications of sewage-oxidation ponds. A novel, low-cost process for microalgal harvesting, based on bio-flocculation in a batch-setting pond, has been demonstrated during 1978 and 1979 at the pilot 0.1-hectare scale system using a shallow paddle-wheel mixed pond. It appears that such a process can meet both the requirements of waste-water treatment, requiring an average 85% removal of suspended algal solids, and of low-cost microalgal biomass production. The key technical problems in designing large-scale microalgal biomass systems for fuels-chemicals production are discussed. The production of hydrogen from water by nitrogen-fixing heterocystous blue-green algae has been demonstrated in both the laboratory and with an outdoor converter; the relative advantages of alternative bio-photosynthesis systems are considered.

039/81 PHOTOSYNTHESIS RESEARCH IN THE USSR. D.O. Hall (King's College, University of London, London (UK)). Nature, vol. 281, p. 255-6 (27 Sept. 1979).

Current research programmes in photosynthesis in the USSR are described. Some of the programmes include: (1) research on hydrogenases, (2) computer facilities, (3) photochemical reduction of low potential compounds, (4) hydrogen-producing systems using model pigment systems, (5) stabilization of chloroplast membranes, (6) construction of fuel cells using immobilized enzymes, (7) carbon, hydrogen, and nitrogen metabolism of photo-synthetic bacteria, (8) methane-producing bacteria, (9) growth of photo-synthetic bacteria under dark and light conditions, (10) efficiency of photo-synthesis and plant productivity, (11) biomass as a future source of energy, (12) mycology, (13) isolation of photo-systems, and (14) factors limiting photo-synthesis in the leaf.

C1. BIOMASS PRODUCTION AND CONVERSION

040/81 SOLID FUEL COOKING STOVES. Documentation Centre (Tata Energy Research Institute, Bombay (India)). Tata Energy Research Institute, 24 Homi Mody Street, Bombay 400023, India (Nov. 1980) 116p.

This survey of the significant world literature on solid-fuel cooking stoves provides a systematic presentation of all available stove designs with suitable illustrations. After a brief introduction, general considerations on the design of cooking stoves are presented. Chapter 3 (on improved cooking stoves) is divided into sections on wood, charcoal, and sawdust and rice-hull stoves. A chapter is included on experimentation with cooking stoves followed by an examination of the influence of socio-cultural values on stove design and utilization and guidelines for extension services. 74 refs.

041/81 THE BRAZILIAN ALCOHOL PROGRAM: A SUCCESSFUL USE OF AN ALTERNATIVE SOURCE OF ENERGY. L.C. Monaco (Biomass Program Secretary of Industrial Technology, Ministry of Industry and Commerce, Brasilia (Brazil)). P. 17-9 of Proceedings of the Bio-Energy '80 World Congress (held Atlanta, GA, USA, 21-4 April 1980). Bio-Energy Council, Washington, DC, USA (1980).

Due to its climate and large surface, Brazil has developed a scientific capacity in different fields of biomass production and its conversion into fuel. Following the event of the oil crisis, this scientific capacity was oriented to the adaptation of gasoline vehicles to run with alcohol-gasoline blends or exclusively with hydrated alcohol. The sound scientific and technological background, the installed industrial capacity, and the government decision to replace petroleum derivatives by alcohol led to the establishment of the PROALCOOL programme, which was initially designed to produce 5.3 million m^3 (not only for fuel, but also for the chemical industry). The distribution of the gasoline-alcohol blend is today spread throughout the country, and one million cars running exclusively on hydrated alcohol will be realized between 1980-1982. In the same period, 270,000 gasoline burning cars will be converted to alcohol. To control the quality of the engines, a network of 11 technological centres was established. New engines,or converted ones cannot be commercialized if the fuel consumption is 20% higher than that obtained for gasoline engines. PROALCOOL is being oriented to prevent land competition between food and energy crops. The distilleries initially established next to sugar mills are now being implanted in new areas with favourable conditions of climate and soil. Presently, the cost of alcohol is competitive with the cost of gasoline. Biomass is now being cultivated to produce charcoal to replace fuel oil and vegetable oils as an alternative for diesel oil.

042/81 POTENTIAL OF LARGE-SCALE ALGAL CULTURE FOR BIOMASS AND LIPID PRODUCTION IN ARID LANDS. Z. Dubinsky, T. Berner and S. Aaronson (Biology Department, Queens College, City University of New York, Flushing, NY 11367 (USA)). P. 51-68 of Biotechnology in Energy Production and Conservation (Proceedings of the First Symposium on Biotechnology in Energy Production and Conservation, held Gattinburg, TN, USA, 10-12 May 1978). J. Wiley and Sons, New York, USA (1979).

This article considers the cultivation potential of marine and brackish-water and sewage-tolerant micro-algae. The uses of these algae, their utilization as a source of lipids, and the economics of mass production of algae are considered. 95 refs.

043/81 DESIGN, OPERATION, AND ECONOMICS OF THE ENERGY PLANTATION AS AN ALTERNATE SOURCE OF FUELS. G.C. Szego, M.D. Fraser and J.F. Henry (Intertechnology Solar Corp., Warrenton, VA (USA)). Vol. 2, p. 1-15 of Proceedings of the Second International Solar Forum (held Hamburg, Fed. Rep. of Germany, 12 July 1978). Deutsche Gesellschaft für Sonnenenergie eV, München, Fed. Rep. of Germany (1978). DM49 for complete vol. 2. of Proceedings.

An energy plantation is a means for producing fuels by collecting and storing solar radiation in plants grown purposely for their fuel value. Appropriate selection of plant species and plantation-cultural practices is the key to producing fuels by this means at attractive costs. This paper discusses how the energy plantation is designed and operated for maximum productivity of plant material. Also included in the discussion are the equipment requirements and the estimated costs for plantation operation. The cost of the fuel produced is estimated to be between US$1.00-1.50 per million BTU (US$0.95 to 1.42/million kJ).

044/81 THE ECONOMIC VALUES OF WOOD RESIDUES AS FUEL. D.A. Tillman (College of Forest Resources, University of Washington, Seattle, WA (USA)). Progress in Biomass Conversion, vol. 1, p. 53-86 (1979). K.V. Karkanen and D.A. Tillman (eds.), Academic Press, New York, USA.

After a brief background discussion, this paper considers the energy value of wood residues (particularly as it is affected by moisture content), develops an opportunity costs-economic value curve for wood residues as a function of moisture content based upon direct combustion to produce steam, and considers the influence of co-generation and electricity generation by utilities on the economic value of residues. The economic value of such residues in traditional raw-material markets are also described. It is seen that moisture is one critical variable that determines the point of maximum economic value of wood residues. 32 refs.

C2. BIOGAS PRODUCTION AND UTILIZATION

045/81 METHANE GENERATION FROM HUMAN, ANIMAL AND AGRICULTURAL WASTES. National Academy of Science, Washington, DC, USA (1977) 120p.

This monograph is an attempt to assess the current state of knowledge and technology, to suggest useful applications and to identify areas where research and development are needed in the field of biogas generation from human, animal and agricultural wastes. It discusses the means by which the natural process of anaerobic fermentation can be controlled for human benefit and how the methane generated by this process can be used as fuel. After an introduction and history, a general description is given of biogas systems. This is followed by a consideration of the economic feasibility of methane production. In considering anaerobic-fermentation technology, biological mechanisms, raw materials, product storage, residues and public health are covered. In examining problems of engineering-process design, emphasis is also placed on operation and maintenance, performance measurement and safety. The document concludes with issues involving research and development needs.

UNCNRSE

CONFERENCE NEWS 3

ENRIQUE IGLESIAS APPOINTED NEW SECRETARY-GENERAL OF UNCNRSE

The Secretary-General of the United Nations, Mr. Kurt Waldheim, announced on 2 January 1981 that he had designated Mr. Enrique V. Iglesias to succeed Mr. Mohamed H. Gherab as the Secretary-General of the UN Conference on New and Renewable Sources of Energy effective 1 February 1981. Mr. Gherab had requested that the UN Secretary-General consider his desire to return to the service of the Tunisian government at the end of January 1981.

Mr. Iglesias, who will report for duties in New York during the month of January at the request of Mr. Waldheim in order to ensure a smooth period of transition, is presently the Executive Secretary of the Economic Commission for Latin America (ECLA). In this and other capacities, Mr. Iglesias has been associated with the United Nations since 1967. Born in Uruguay, the new Secretary-General of the Conference brings to his new job experience gained in a career in economics which included 15 years in the University of Montevideo, where he was professor and director of that University's Institute of Economics.

EXPERTS TO DISCUSS NON-TECHNICAL ISSUES

Supplementing the substantive preparations, the Conference Secretariat has organized special studies of major issues that cut across all energy sources. Six Ad Hoc Groups of Experts have begun to examine the following issues: information flows; financing; education and training; research and development and transfer of technology; rural energy, including utilization of energy in agriculture; and industrial issues, including utilization of energy in transportation and allied sectors.

Scheduled for December 1980 and January 1981, the Ad Hoc Groups of Experts will meet as the next step towards the synthesis of findings and recommendations for submission to the Preparatory Committee.

The main task of the Ad Hoc Expert Group on Information Flows is to recommend measures to improve the availability and use of information essential for the development and utilization of new and renewable sources of energy.

The Group is a composite of experts from the field of information science, representative user communities from both the private and public sectors involved with the development and use of new and renewable sources of energy, individuals with in-depth knowledge and understanding of the key elements in the process of policy decisions in the fields of finance, commercial and industrial development, research and development education and training, and technology transfer. This Group will examine a discussion paper and relevant background materials prepared for its consideration, and review the present situation and consider measures for its improvement, including financing and costs, and institutional mechanisms. Finally, the Group will recommend ways and means to increase the effective use of information, to make it more readily available, and to facilitate the international exchange of transfer of information. With special regard for conditions and requirements of developing countries, the Group is expected to arrive at a concrete plan of action at the national, regional and international levels which may include: 1) national programmes for establishment or enhancement of the existing information collection and dissemination infrastructure; 2) establishment of regional information clearinghouses and information exchange mechanisms; and 3) the establishment of an international information network for exchange and dissemination of information on new and renewable sources of energy in the context of the proposed network for exchange of scientific and technological information.

Faced with the task of finding out what makes investment in new and renewable sources of energy different from other types of investment in terms of risk and scale of projects, the Ad Hoc Expert Group on Financing will look into the financial flows and constraints in developed and developing countries. The Group will examine sources of funds (private, local and regional sources), related fiscal policies and how these funds are used in research and development, training, infrastructure and other areas, in order to arrive at proposals for adapting and/or expanding existing institutions or the need for new institutions.

The Ad Hoc Expert Group on Education and Training will examine the present situation with a view to identifying the types of skilled, technical and management personnel needed in both the public and private sectors to facilitate the enhanced use of new and renewable sources of energy; undertaking a global inventory of existing institutions, facilities, programmes and other mechanisms providing education and training for such personnel; arriving at rough estimates of resources needed to meet this demand; and evaluating the adequacy of available national, regional and global institutions in providing training in these fields.

The Group is expected to arrive at measures to improve the present situation for international collaboration and co-operation on available information, facilities, programmes, researches and their funding; for the development of national strategies necessary to generate skilled, technical and management personnel; and for the development of curricula and training

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materials for teaching and demonstration programmes with respect to new and renewable energy technologies.

The Ad Hoc Expert Group on Research and Development and Transfer of Technology will review the current situation at the national, regional and global levels and, after weighing the constraints impeding the access of developing countries to new and renewable energy technology, is to arrive at measures to be considered for action at all these levels.

The review will be conducted through a survey of the current status of research, development and demonstration activities in the area of new and renewable energy technologies as distributed geographically in terms of entities, staffing, expenditures and end-use applications; identification of technology ready for testing at pilot plant and commercial levels as well as research projects expected to lead to the development of relevant technologies in the medium-term future; and market penetration studies to estimate market potential for currently available technologies.

A study of constraints would encompass such factors as the structure of the international market for new and renewable sources of energy; multi-national networks of information flows and access to information; and imbalanced, inadequate and insufficient research, development and demonstration resources, funding and manpower.

This process should lead the Group towards the formulation of proposals and recommendations for action at national, regional and international levels. Action at the international level aims at the organizing and funding of a well-orchestrated global effort to develop technologies useful to developing countries. This would entail global funding for new-and-renewable-sources-of-energy technologies; establishing an international institute for research and development where testing and dissemination of technologies for new and renewable sources of energy can be conducted; and the participation of scientists and technologists from developing countries in research, development and demonstration activities as carried out in developing countries.

Action recommended at the regional level could encourage co-operation among developing countries to strengthen collectively their adaptation and generation of new and renewable sources of energy, namely by reinforcing their regional centres for the transfer of technology; exchange of engineers and scientists working in this field; and, where possible, joint-production facilities in order to take advantage of economies of scale.

The Ad Hoc Expert Group on Rural Energy, including Utilization in Agriculture, will address itself in depth to the special issues and problems associated with the development, supply and utilization of energy resources in rural areas. Since a large proportion of urban population also depends on the energy from rural areas, energy supply for this sector will also be considered.

The Group will examine the energy requirements and consumption patterns in rural areas as affected by the availability of energy resources, technologies, systems, ecological considerations, costs and the socio-cultural factors enhancing or inhibiting more widespread use of new energy technologies in rural areas. It will then proceed to a review and diagnosis of the current situation at the national, regional and global levels of available technologies, and the major constraints and problems (economic, financing, infrastructure, manpower, research, development and demonstrations on new technologies) encountered and will recommend possible measures, including policy options at the national, regional and global levels, for a programme of action to overcome these constraints.

The objectives of the Ad Hoc Expert Group on Industrial Issues, including Utilization in Transportation and Allied Sectors are to conduct a review and analysis of the present situation in the area of new and renewable sources of energy relating to the industrial, transportation and allied sectors; to identify possible measures for the solution of the problem at the national, regional and global levels by exploiting the advantages and/or overcoming the constraints brought to light; and to prepare a report with selected main facts, analyses, proposals and recommendations on identified areas of priority.

The Group will review the current situation from two aspects: "energy for industry" and "industry for energy".

From the aspect of "energy for industry", the Group will consider the impact of new and renewable sources of energy on the pattern of energy availability, on the industrial development pattern, and on transportation systems; the impact of their share in the industrial energy balance of developing countries; and the need for development of agro- and small-scale industries with special reference to utilization of new and renewable sources of energy, especially in remote and rural areas.

As to "industry for energy", the Group will examine existing experience and look into future possibilities of equipment production in developing countries for the exploitation and utilization of new and renewable sources of energy. Close attention will be given to problems regarding the planning and organization of local production and the maintenance and operation of equipment for the new-and-renewable-sources-of-energy sector. New aspects of "energy management" that may arise from the use of new and renewable sources of energy in industry and transportation will be considered.

The Group is proposing measures for consideration at national, regional and global levels to exploit the advantages and/or overcome the constraints identified by the Group.

On a national level, they will discuss suggestions concerning national energy planning for industrial development and the transportation sector based on the use of new and renewable sources of energy; the organization of distribution-consumption systems of new and renewable sources of energy for use in industry and transportation; and the establishment of national bodies dealing specifically with new and renewable sources of energy-related industrial problems, paying particular attention to information, research and development and engineering.

On an international level, emphasis will be placed on international co-operation in joint projects (technologically and financially) aimed at the use of new and renewable sources of energy for industrial transportation systems, and the technical assistance needed for the identification of site-specific and sector-specific problems and opportunities in the use of new and renewable sources of energy for industry and transportation (including research, development, pilot and prototype testing).

- M.E. Leung

NATIONAL FOCAL POINTS FOR UNCNRSE

In order to facilitate the efforts of the UNCNRSE, governments have appointed individuals or institutions to serve as national focal points, to help co-ordinate efforts in their respective countries to participate in and contribute to the UNCNRSE. For our readers' information, we are presenting a list of the approximately 90 countries who have designated official national focal points in two parts, the first of which appears below:

ALGERIA

Ministère de l'énergie et de
l'industrie pétrochimique

AUSTRALIA

Energy Section
Department of Foreign Affairs
Canberra, ACT, 2600

cc: International Section
Department for National
Development and Energy
Canberra, ACT, 2600

AUSTRIA

Austrian Federal Ministry for
Foreign Affairs
Abteilung III.3
Vienna

BAHAMAS

Mr. Oris S. Russel
Permanent Secretary
Ministry of External Affairs

BAHRAIN

Mr. Rashid Al-Dhubeib
Head of Companies and Organization
Affairs in Oil Directorate
Ministry of Development and Industry

BARBADOS

National Council, Science and
Technology

BELGIUM

Service Energie (B.24) du Ministère
des Affaires étrangères
Commerce extérieur et de la
Coopération au Développement

BOLIVIA

Ministerio de Energía e Hidrocarburos

BOTSWANA

The Permanent Secretary
Ministry of Mineral Resources and
Water Affairs
Private Bag 0018
Gaborone

BRAZIL

Divisao de Energia e Recursos Minerales
(DEM)
Ministério das Relaçoes Exteriores
c/o Brazilian Mission to the United
Nations
747 Third Avenue, 9th floor
New York, NY 10017

BURUNDI

Département de l'Energie
Ministère de l'Energie et des Mines

BYELORUSSIAN SOVIET SOCIALIST REPUBLIC

State Plan Committee of the Byelo-
russian Soviet Socialist Republic

CANADA

International Energy Policy Division
Department of External Affairs
Ottawa

and

Canadian Government Steering Committee
of UNERG

both c/o The Permanent Mission of Canada
to the United Nations
866 United Nations Plaza,
Suite 250, New York, NY 10017

CENTRAL AFRICAN REPUBLIC

Monsieur Gaston Lekoua
Ingénieur Electrician-Mécanicien
Directeur Général de l'Energie
Centrafricaine (ENERCA)
B.P. 880, Bangui

CHILE

Comision Nacional de Energía
Teatinos 120, Piso 14
Santiago

COLOMBIA

Subsecretaria de Asuntos Ecnomicos
de la Cancilleria
Ministerio de Relaciones Exteriores
de Colombia
(with the co-operation of the
Ministerio de Minas y Energía)

CONGO

Mr. Imangue Jean Joseph
Directeur de l'Energie et des
Carburants
Ministère des Mines et de l'Energie
B.P. 2120, Brazzaville

COSTA RICA

Oficina de Planificación Nacional y
Política Económica

CUBA

Ministerio de Relationes Exteriores
de la República de Cuba

CYPRUS

Ministry of Commerce and Industry

CZECHOSLOVAKIA

Federal Ministry of Technology and
Investments
Attention: Mr. Sláva Wanek, Director
Department of Foreign Relations
Slezská 9, 120 29 Praha 2

DEMOCRATIC YEMEN

Ministry of Planning
P.O. Box 1193, Aden

DENMARK

Mr. H.P. Houlberg
Office of International Co-operation
in Energy Policy and Industrial
Policy
Ministry of Foreign Affairs
Asiatisk Plads 2
1448 Copenhagen K

ECUADOR

Instituto Nacional de Energía
c/o Ministerio de Relaciones
Exteriores
Carrion y 10 de Agosto
Quito

EGYPT

Supreme Council for Energy

ETHIOPIA

Ethiopian National Energy Committee
P.O. Box 486

FINLAND

Mr. Ulf Sundqvist
Minister for Trade and Industries
Ministry for Foreign Affairs
Department of Foreign Trade
Hallituskatu 3B
00170 Helsinki 17

FRANCE

Mr. Pierre Desprairies
President de la Comission "Energie"
du VIIIème Plan

GERMAN DEMOCRATIC REPUBLIC

Ministerium für Kohle und Energie
Abteilung Internationale Zusammenarbeit
Karl-Liebknecht-Strasse 34
1020 Berlin

GERMANY, FEDERAL REPUBLIC OF

Auswärtiges Amt
Referat 405
Bonn

SCHEDULE OF CONFERENCE MEETINGS

Ad-Hoc Groups of Experts

Information Flows	8-12 December 1980	Geneva
Finance	15-19 December 1980	Geneva
Research and Development, and Transfer of Technology	5- 9 January 1981	New York
Industrial issues and utilization in transportation and other allied sectors	12-16 January 1981	UNIDO-Vienna
Education and Training	19-23 January 1981	New York
Rural energy and utilization in agriculture	26-30 January 1981	UNCHS-Nairobi

Major Meetings

Inter-agency meeting	8-10 October 1980	Geneva
Synthesis Group	17-27 February 1981	New York
Preparatory Committee (3rd Session)	30 March-17 April 1981	New York
Preparatory Committee (4th Session)	8-26 June 1981	New York
Conference	10-21 August 1981 preceded by one week of pre-conference consultations	Nairobi-Kenyatta Conference Centre

LIST OF MEETINGS ON ISSUES RELATED TO NEW AND RENEWABLE SOURCES OF ENERGY ORGANIZED BY NON-GOVERNMENTAL ORGANIZATIONS

Annual Meeting of European Environment Bureau (EEB)	Mid-December 1980	Brussels, Belgium
International Project for Soft Energy Paths (EPSEP) Meeting	15-19 January 1981	Rome, Italy
UN/NGO National Meeting on "Lifestyles and National Resources: The Federal Republic of Germany and the Third World"	13-15 February 1981	Bonn, Fed. Rep. of Germany
Committee on Science and Technology in Developing Countries (COSTED) Seminar "Energy Options for Developing Countries"	23-27 February 1981	Madras, India
ENERGY 2000	March 1981	Tunis, Tunisia
Department of Public Information/Non-Governmental Organizations Conference "Energy, Development and Survival"	1- 4 May 1981	New York, USA
International Development Conference on Issues including Energy	12-14 May 1981	Washington, DC, USA
Conference on Energy involving Non-Governmental Organizations from USA, Canada, Mexico, Japan, organized through Metro-Centre, YMCA	Early July 1981	Seattle, USA
U.S. Regional Conference on Energy, Non-Government Liaison Service (New York)	Late July 1981	Denver, USA
Non-Governmental Organizations Forum, UN Conference on New and Renewable Sources of Energy	10-14 August 1981 (approximate date)	Nairobi, Kenya
International Solar Energy Society Congress and Exhibition	23-29 August 1981	Brighton, UK
Meeting focussing on Energy and Finance with North-South Institute, World Bank and Non-Governmental Liaison Service (New York)	Late October 1981	Alberta, Canada

046/81 FERTILIZERS AND ENERGY FROM ANAEROBIC FERMENTATION OF SOLID WASTES. R.S. Holdon and B. Winstrom-Olsen (Department of Applied Microbiology, University of Strathclyde, Glasgow, Scotland (UK)). Handbook of Organic Waste Conversion, p. 383-408. M.W.M. Bewick (ed.), Van Nostrand Reinhold, New York, USA (1980).

This paper considers anaerobic digestion as a microbial process and examines its future prospects. The type of wastes, current state of anaerobic technology, farm-scale technology and advantages of anaerobic digestion are presented. Energy accounting, the substitution of primary fossil fuel and planning of biogas digesters are considered. Process improvements and new reactor designs are also examined. 60 refs.

047/81 FARM-SCALE GENERATION OF BIO-GAS. P.R. Goodrich, R.J. Gustafson and K.L. Hauer (Department of Agricultural Engineering, University of Minnesota, St. Paul, MN 55108 (USA)) and V. Larson. Energy, vol. 4, p. 249-61 (1979).

A farm-scale research and demonstration digester has been constructed, operated and monitored on a private medium-sized swine farm. Materials-handling problems have been studied. Biogas from the digester is used in a motor generator set to be integrated into the farmstead energy system. The digester has been monitored to determine operational characteristics, amount of energy produced and efficiency of energy production. 2 refs.

048/81 KINETIC STUDIES ON BIO-GAS EVOLUTION FROM BUFFALO DUNG. R.P. Rastogi, H.J. Singh and K. Kishore (Department of Chemistry, University of Gorakhpur, Gorakhpur 273001 (India)). Indian Journal of Technology, vol. 1, no. 1, p. 5-10 (1979).

The influence of temperature, expansion and incubation period on the kinetics of the anaerobic digestion of buffalo excrement is reported. The effect of adding various substances, such as α-naphthylamine, diphenylamine, EDTA and hydroquinone, are described. 18 refs.

D. WIND ENERGY

049/81 FEASIBILITY STUDY OF WINDMILLS FOR WATER SUPPLY IN MARA REGION, TANZANIA. H.J.M. Beurskens (Department of Physics, University of Technology, Eindhoven (Netherlands)). Steering Committee on Wind-Energy for Development Countries, P.O. Box 85, Amersfoort, Netherlands (March 1978). 89p.

This report gives a very broad analysis of the factors involved in using windmills for water pumping for village water supply and local gardening in the Mara region of Tanzania. Lake Victoria and wells are to be the sources. Taking into consideration as many variables as possible, the report suggests different equipment, sites and appropriate operating procedures. The annexes include: economic information on existing windmill projects in northwest Tanzania; the types of horizontal-axis windmills; and meteorological reports from the East African Meteorological Department for Musoma and Mwanza.

050/81 THE EXPERIMENT IN SAN RAFAEL, S.L.P. (LA EXPERIMENCIA EN SAN RAFAEL, S.L.P.). Boletín del Instituto de Investigaciones Eléctricas, vol. 4, no. 8-9, p. 32-4 (1980).

An integrated-energy system project was begun in 1977 in San Rafael, Mexico, a semi-arid pastoral community with a population of 700-800, by the Instituto de Investigaciones Electricas, Volunteers in Technical Assistance and the General Rural Electrification Administration of CFE. Since the major problem of the community was the availability of potable water, prototypes of a 200-W wind generator, a Savonius wind-powered pump and a sail windmill were installed in the village to evaluate their operation under local conditions. It was decided, in view of the unsuccessful operation of the Savonius pump and wind generator, to select the sail windmill. In June 1980, the sail windmill began pumping water. Attachments for grinding, pounding and milling will be added in the future. Three other pumps will be installed in the village to supplement the initial one.

En 1977, el Instituto de Investigaciones Eléctricas, los Voluntarios de Asistencia Técnica y la Dirección de Electrificación General Rural (CFE), iniciaron un proyecto integrado de energía en San Rafael, México, una población de unos 700 a 800 habitantes, ubicada en un medio semiárido. Dado que el mayor problema de la comunidad era la disponibilidad de agua potable, se instalaron en la aldea los prototipos de un generador eólico de 200-W, de una bomba Savonius accionada por el viento, y de un molino de viento de vela, para evaluar su funcionamiento bajo las condiciones locales. En vista de los resultadoes poco satisfactorios de la bomba Savonius y del generador eólico, se decidió utilizar el molino de vela. En junio de 1980 se comenzó a bombear agua con este aparato. En el futuro se le agregarán implementos para molienda y trituración, y se instalarán tres bombas más en la misma aldea, que complementarán el trabajo de la primera.

E. ENERGY STORAGE

051/81 REVIEW OF THERMAL STORAGE MATERIALS FROM THE VIEW POINT OF SOLAR ENERGY APPLICATION. P.C. Pande and H.P. Garg (Central Arid Zone

Research Institute, Jodhpur (India)). P. 191-202 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

The thermal-energy and chemical storage of solar energy are reviewed for evaluating the feasibility of their practical utilization in solar energy appliances for agricultural purposes. Both sensible-heat (temperature change) and latent-heat (phase change) storage media with different systems are discussed in detail for high- as well as low-temperature storage. The performance of both sensible- and latent-heat materials are compared after investigating their heat capacities, melting points,enthalpies of fusion, density, crystallization behaviour, stability, corrosive nature, thermal conductivity and other physical and chemical properties. The hydration-dehydration equilibria is discussed. Storage by inorganic oxide-hydroxides such as $MgO\text{-}Mg(OH)_2$ and $CaO\text{-}Ca(OH)_2$ is investigated.

052/81 PHOTOCHEMICAL CONVERSION AND STORAGE OF SOLAR ENERGY. G. Stein (Hebrew University, Jerusalem (Israel)). P. 1-25 of Proceedings of the International Conference on Photo Conversion and Storage of Solar Energy (held London, Ontario, Canada, 24 Aug. 1976). NTIS.

The subject of this conference is the chemical utilization of solar energy through systems in which the quanta of radiation from the sun are not degraded to heat but are utilized in atomic or molecular systems which undergo chemical change. In these chemical changes endergenic processes occur storing part of the quantum energy in the form of labile intermediates. The problem to examine is whether the systems required for the chemical utilization and storage of solar energy appear to have a chance of competing economically with other forms of solar energy utilization. It was concluded that it now appears that some photochemical devices may in the near future become competitive with dry photovoltaic devices. It seems that the viability of photochemical devices may be relatively the greatest in specifically selected geographical areas and in societies in which highly centralized power generation has not yet developed and is neither economically nor socially desirable for the greatest goal of the country and population involved.

053/81 HYBRID HEAT STORAGE APPARATUS. E. Morawetz and B.I. Morawetz (to Teknoterm Systems AB). Swedish Patent 7,712,829 (July 1979) 10p. In Swedish.

A heat-storage system is presented, where water and paraffin are used as the heat media. Energy is stored as latent heat in the paraffin. The energy is transported from the solar collector with the water, which is then sprayed on the paraffin.

F. SOCIO-ECONOMIC ASPECTS

054/81 ENERGY OPTIONS: CHANGING VIEWS FROM INDIA. L.I. Rudolph and C.S. Lenth (Department of Political Sciences, University of Chicago, Chicago, IL (USA)). Bulletin of Atomic Scientists, vol. 34, no. 6, p. 6-8 (1978).

This article is a challenge to A.K.N. Reddy's article on "Energy Options for the Third World", in which a significant question about high-technology, macro-planning approaches to Indian energy development is raised. The main point of contention is that there is as yet no clear evidence that a centralized and high-technology energy policy is not necessarily more incompatible with the needs and styles of village life than a decentralized low-technology energy policy. It is felt that what is known about the complex relationship between science technology and social change have been understated in Reddy's paper while the degree to which technologies are a controlling factor in the achievement of social and economic objectives has been overstated. The authors challenge his mathematically-oriented energy budgets based on input-output matrices as being insensitive to production, energy policies and uses and propose that a strategy be considered that will take into account the complex motives and objectives and the ambiguous consequences that accompany attempts to achieve social and economic development. It is also pointed out most of what has come to be called non-commercial energy does indeed have a commercial component attached to it, as in the case of human and animal labour being hired out. While biogas plants, decentralized power generation and village-centred technology fit well with the emphasis on rural development and village self-sufficing, below the rhetoric, the authors feel that there exists conflict and uncertainly over what should be done to promote growth and redistribution. Reddy's view of the future is seen to offer a means of avoiding such conflicts and uncertainties but could include more awareness of the social and political conditions that shape the technologies and constrain their ability to change societies rather than be changed by them. 8 refs.

055/81 ENERGY USE IN RURAL INDIA. R. Revelle (Center for Population Studies, Harvard University, Cambridge 02138, MA (USA)). Science, vol. 192, p. 969-75 (1976).

This article considers India, and especially rural India, as a partially closed energy ecosystem and gives a great variety and quantity of statistics to illustrate the energy flow. These data include the energy consumption and expenditure for many forms of human (men, women and children) activity. This is presented in relation to the total energy-flow picture involving all types of energy sources and sinks. Though the main thrust of the article is statistical, it concludes by stating that with its increasing population India must move to a two-crop per year system on most agricultural land and thus, must also consider the increased use of external energy sources (mostly hydro-electric and fossil fuel) for irrigation, fertilizer and draft power. It also suggests that better use of all energy sources is needed. 36 refs.

056/81 THE ENVIRONMENTAL IMPACTS OF PRODUCTION AND USE OF ENERGY, PART III: RENEWABLE SOURCES OF ENERGY. United Nations Environmental Programme, Nairobi (Kenya). ERS-7-80 (Aug. 1980). United Nations Environment Programme, Nairobi, Kenya. 132p.

This report was prepared on the basis of contributions from a number of scientists and of numerous sources to provide the basis for considering the environmental aspects of renewable sources of energy. After an initial introduction, the following energy sources are treated in detail: geothermal, solar, wind, marine, hydro, and biomass energy. Each topic is covered by examining the resource, method of utilization and the various types of environmental impacts. Particular attention is given to the impact on land, noise, airborne effluents and thermal discharges for geothermal energy, and physical, geochemical, biogeochemical, biological and socio-economic aspects for hydropower generation. 250 refs.

SELECTED ARTICLE

Presented at the Research Planning Workshop on Energy for Rural Development held at the Indian Institute of Management, Ahmedabad, India, 27-29 December 1979, and printed in Documentation Notes, p. 5-14 (January 1980) (Tata Energy Research Institute, 24 Homi Mody Street, Bombay 400 023, India). Reprinted by permission.

REPLACEMENT OF COWDUNG BY FERMENTATION OF AQUATIC AND TERRESTRIAL PLANTS FOR USE AS FUEL, FERTILIZER AND BIOGAS PLANT FEED

by

C. R. Das
Tata Energy Research Institute, 24 Homi Mody Street, Bombay 400 023, India

and

Sudhir D. Ghatnekar
Environmental Science Division, C.C. Shroff Research Institute
Excel Estate, S.V. Road, Bombay 400 062, India

* * *

The authors have indicated in a separate communication that the plastic bags mentioned in the article were chosen because they are available at the village level as chemical fertilizer is delivered in plastic bags inserted in jute bags or plywood barrels and that pilot plant-scale trials have confirmed the results obtained by the bench-scale trials reported in the paper.

INTRODUCTION:

Eighty-five percent of Indian population live in villages and ninety-eight percent of household energy requirement of the rural population is for cooking. Consumption of cowdung and firewood are the main fuels, amounting to 20 million and 144 million tonne of coal equivalent respectively.

As cowdung is not available in adequate quantities, dependence on firewood has increased resulting in deforestation, decrease in family income and drop-out from schools, as the women and children have to forage for firewood which now takes about 8 hours.

Efforts were made to produce the replacement material by a method which is cheap, uses the simplest possible technology and production process and is within the reach of the poorest.

The results of the investigations, which were started in May, 1979 as proof of concept studies are presented in the paper.

In the July/August 1978 issue of "Mother Earth News", Mr Dycus described a method of producing manure from weeds and garden wastes (1). We decided to test the technique to produce a fermented mass under Indian conditions and determine if it can be used as fuel and biogas plant feed apart from fertilizer.

We felt that:

(i) as the fermented mass has not undergone the digestive process weight per weight it will have higher calorific value and produce more biogas than cowdung.

(ii) when product is made into cakes similar to cowdung ones and dried, they can be used as fuel. As leaves, weeds and easily collectable plants will be used, foraging time will decrease and discourage cutting down trees for firewood. Since less time will be required to prepare the biodung cakes, the women can return to work in the fields once again to supplement the family income and the children need not drop out from schools. If the dry cakes are produced in large quantities and sold as in case of cowdung cakes, they can serve as a source of income.

(iii) if the fermented mass can produce biogas then it will bring gobar gas plants within the reach of those who do not possess cattle.

(iv) it will eliminate the problem of collection of large quantities of cowdung for community biogas plants which has been one of the limiting factors in their development.

(v) it will find use for land and aquatic weeds, undergrowths, foliage of energy plantation. It will also provide a strong motivation, for eradication of weeds, particularly, water hyacinth and african payal as the dried cakes can be sold.

(vi) it will eliminate the necessity of using night soil as supplement to cowdung in biogas plants thereby make the biogas acceptable for cooking and release the night soil for direct use as manure.

Materials:

The following botanical species served as experimental materials:

(i) Water Hyacinth	(*Eichhornia crassipes*)
(ii) Water Lettuce	(*Pistia stratiotes*)
(iii) African Payal	(*Salvinia auriculata*)
(iv) Duck Weed	(*Lemna trisulca*)
(v) Water Spinach	(*Ipomoea aquatica*)
(vi) Ramban, Cattail	(*Typha angustifolia*)
(vii) Lucaena, Ipil-ipil	(*Leucaena leucocephala*)
(viii) Morning Glory	(*Ipomoea pestigridis*)
(ix) Paragrass	(*Brachiaria mutica*)
(x) Purple Nutsedge	(*Cyprus rotondus*)
(xi) Durva Grass	(*Stylo species*)

EXPERIMENTS:

All the experiments were carried out at the C. C. Shroff Research Institute, Bombay, with the involvement of ten persons. The experiments were carried out using 1.5 kg, 5 kg and 50 kg of the weeds on fresh weight basis. At the start of the experiments and every 4th day thereafter, 0.5 lts water was required to be added to 1.5 kg batches, 2 lts for 5 kg batches and 10 lts for 50 kg batches. Ten sets of experiments were carried out and their results have been attached in tabulated form.

The first five sets of experiments were carried out with used white opaque PVC bags available with the Institute. The next five sets of experiments were carried out with transparent polyethylene bags to establish their suitability for the process and verify if similar results are obtained as in case of opaque white P.V.C. bags. The bags were kept in the hot sun for anaerobic digestion and opened every fourth day to release the accumulated gases, for visual inspection and addition of water. Addition of putrefying bacteria was avoided. All the experiments are replicated twice.

Details:

(i) *Set No. 1:* The ingredients were water hyacinth and paragrass. Fermentation was complete in 21 days in the first eight experiments, it was incomplete in the other three.

(ii) *Set No. 2:* The ingredients were water lettuce and paragrass. Fermentation was complete in 15 days in eight out of 11 cases and was incomplete in rest of the three cases.

(iii) *Set No. 3:* The ingredients were duck weed and water hyacinth. Here the fermentation was complete in 20 days in all cases.

(iv) *Set No. 4:* The experiments could not be completed due to unexpected rains.

(v) *Set No. 5:* The ingredients were cattail, water lettuce and lucaena. Unshredded, shredded, individual ingredients and their mixtures were tried out in 16 experiments.

Amongst the unshredded individual ingredients, fermentation did not take place, only in case of cattail. Water lettuce fermented well in 16 days.

Amongst the unshredded mixture of ingredients, cattail remained unfermented in the mass even after 30 days. The mixture of water lettuce and lucaena fermented very well in 21 days.

In cases of shredded ingredients and their mixtures well fermented mass was obtained in every case thereby proving shredding improves the fermentation process.

(vi) *Set No. 6:* The ingredients were water hyacinth, water lettuce and durva grass. Transparent polyethylene bags were used from this experiment onwards. Fermentation was excellent in all cases except in that of durva grass. In case of durva grass, fermentation remained incomplete even after 30 days.

It was noted that addition of water lettuce accelerated the fermentation process and the fermented mass was more homogeneous than the batches which did not contain water lettuce.

(vii) *Set No. 7:* The ingredients were water hyacinth, water lettuce and durva grass. This set of experiment was a repetition of Set No. 6 to determine if repeatable results can be obtained by use of transparent polyethylene bags.

The conditions were kept the same in all cases except for durva grass. A well fermented mass was obtained in 15 days when the durva grass was mixed with cowdung in 1:1 ratio. This indicated that fermenting agents will be useful in case of grasses, reeds and fresh straws which contain a high percentage of lignin.

(viii) *Set No. 8:* The ingredients were african payal and water spinach in 5 kg batches. Fermentation was complete in 20 days in all cases and the fermented materials were similar in appearance.

(ix) *Set No. 9:* The ingredients were water hyacinth, water lettuce, african payal, duck weed, water spinach, cattail, morning glory, paragrass, purple nutsedge, durva grass and lucaena. The batches were of 5 kg each.

The fermentation period was 10 days in case of duck-weed, 15 days in case of african payal, 18-19 days for water lettuce and water hyacinth. Fermentation remained incomplete in all other cases.

(x) *Set No. 10:* The ingredients were a heterogenous mixture of (i) aquatic weeds, (ii) land weeds, (iii) land and aquatic weeds, (iv) land weeds with cowdung, (v) aquatic weeds with cowdung, and (vi) aquatic and land weeds with cowdung. The total weight of the mixture was increased to 50 kgs and 1 kg of cowdung was added in last three experiments.

Fermentation was complete in all cases, the time varying from 14 to 33 days. In the case of land weeds 20 lts of water was needed to be added after the 15th day instead of 10 lts as in other cases.

SET NO. 1

Started on:

1979 MAY 14

Sl. No.	Ingredients	Wt. in kg.	Total Wt. in kg.	Duration of Fermentation Days	Dry Wt. (Sun Dried) in kg.	Remarks
1.	Water Hyacinth. Paragrass.	5.000 —	5	21	2.400	Well Fermented
2.	Water Hyacinth. Paragrass.	4.500 0.500	5	21	0.200	Well Fermented
3.	Water Hyacinth. Paragrass.	4.000 1.000	5	21	1.050	Well Fermented
4.	Water Hyacinth. Paragrass.	3.500 1.500	5	21	1.220	Well Fermented
5.	Water Hyacinth. Paragrass.	3.000 2.000	5	21	0.680	Well Fermented
6.	Water Hyacinth. Paragrass.	2.500 2.500	5	21	0.700	Well Fermented
7.	Water Hyacinth. Paragrass.	2.000 3.000	5	21	0.544	Well Fermented
8.	Water Hyacinth. Paragrass.	1.500	5	21	0.540	Well Fermented
9.	Water Hyacinth. Paragrass.	1.000 4.000	5	21	0.540	Fermentation Incomplete
10.	Water Hyacinth. Paragrass.	0.500 4.500	5	21	1.480	Fermentation Incomplete
11.	Water Hyacinth. Paragrass.	— 5.000	5	21	1.200	Fermentation Incomplete

SET NO. 2

Started on:

1979 MAY 14

Sl. No.	Ingredients	Wt. in kg.	Total Wt. in kg.	Duration of Fermentation Days	Dry Wt. (Sun Dried) in kg.	Remarks
1.	Water Lettuce.	5.000	5	15	0.960	Well Fermented
2.	Water Lettuce. Paragrass.	4.500 0.500	5	15	0.412	Well Fermented
3.	Water Lettuce. Paragrass.	4.000 1.000	5	15	0.948	Well Fermented
4.	Water Lettuce. Paragrass.	3.500 2.000	5	15	2.160	Well Fermented
5.	Water Lettuce. Paragrass.	3.000 2.000	5	15	1.820	Well Fermented
6.	Water Lettuce. Paragrass.	2.500 2.500	5	15	2.420	Well Fermented
7.	Water Lettuce. Paragrass.	2.000 3.000	5	15	1.048	Well Fermented
8.	Water Lettuce. Paragrass.	1.500 3.500	5	15	2.320	Well Fermented
9.	Water Lettuce. Paragrass.	1.000 4.000	5	15	2.408	Fermentation Incomplete
10.	Water Lettuce. Paragrass.	0.500 4.500	5	15	2.000	Fermentation Incomplete
11.	Paragrass.	5.000	5	15	1.200	Fermentation Incomplete

SET NO. 3

Started on:

1979 MAY 14

Sl. No.	Ingredients	Wt. in kg.	Total Wt. in kg.	Duration of Fermentation Days	Dry Wt. (Sun Dried) in kg.	Remarks
1.	Duck Weed.	5.000	5	20	—	Well Fermented
2.	Duck Weed. Water Hyacinth.	4.500 0.500	5	20	0.380	Well Fermented
3.	Duck Weed. Water Hyacinth.	4.000 1.000	5	20	1.000	Well Fermented
4.	Duck Weed. Water Hyacinth.	3.500 1.500	5	20	1.040	Well Fermented
5.	Duck Weed. Water Hyacinth.	3.000 2.000	5	20	—	Well Fermented
6.	Duck Weed. Water Hyacinth.	2.500 2.500	5	20	0.740	Well Fermented
7.	Duck Weed. Water Hyacinth.	2.000 3.000	5	20	0.340	Well Fermented
8.	Duck Weed. Water Hyacinth.	1.500 3.500	5	20	0.380	Well Fermented
9.	Duck Weed. Water Hyacinth.	1.000 4.000	5	20	0.180	Well Fermented
10.	Duck Weed. Water Hyacinth.	0.500 4.500	5	20	0.780	Well Fermented
11.	Water Hyacinth.	5.000	5	20	0.520	Well Fermented

Started on: 1979 MAY 14 SET NO. 4

Sl. No.	Ingredients	Wt. in kg.	Total Wt. in kg.	Duration of Fermentation Days	Dry Wt. (Sun Dried) in kg.	Remarks
1.	Morning Glory	50.000	50	21		Unexpected rains, Experiments inconclusive
2.	Morning Glory Grass (Durva)	25.000 25.000	50	21		—do—
3.	Purple Nut Sedge Paragrass.	25.000 25.000	50	21		—do—
4.	Purple Nut Sedge	50.000	50	21		—do—
5.	Leucaena Paragrass.	25.000 25.000	50	21		—do—
6.	Leucaena Purple Nut Sedge.	25.000 25.000	50	21		—do—
7.	Leucaena Purple Nut Sedge. Paragrass.	17.000 17.000 17.000	51	21		—do—

Started on: 1979 MAY 14 SET NO. 5

1.	Typha Water Lettuce Leucaena	Whole	1.700 1.700 1.700	5.100	30	0.528	Typha does not ferment well
2.	Typha Leucaena	Whole	2.500 2.500	5.000	30	0.416	—do—
3.	Leucaena Water Lettuce	Whole	2.500 2.500	5.000	21	0.526	Well fermented
4.	Typha Water Lettuce	Whole	2.500 2.500	5.000	26	0.295	Typha does not ferment well.
5.	Typha Water Lettuce Leucaena	Cut into pieces	1.700 1.700 1.700	5.100	30	0.450	—do—
6.	Typha Leucaena	Cut into pieces	2.500 2.500	5.000	30	0.420	Well Fermented
7.	Leucaena Water Lettuce	Cut into pieces	2.500 2.500	5.000	26	0.400	Well Fermented
8.	Typha Water Lettuce	Cut into pieces	2.500 2.500	5.000	30	0.428	Well Fermented
9.	Typha	Whole	5.000	5.000	30	0.440	Fermentation Incomplete
10.	Water Lettuce	Whole	5.000	5.000	16	0.375	Well Fermented
11.	Leucaena	Whole	5.000	5.000	21	0.410	Fermentation Incomplete
12.	Typha	Cut into pieces	5.000	5.000	30	0.400	Well Fermented
13.	Water Lettuce	—do—	5.000	5.000	15	0.470	Well Fermented
14.	Leucaena	—do—	5.000	5.000	21	0.420	Well Fermented
15.	Mixed	—do—	8.200	8.200	30		Well Fermented

Started on: 1979 AUG 21 SET NO. 6

1.	Water Hyacinth Water Lettuce Grass (Durva)	0.500 0.500 0.500	1.500	21	0.222	Well Fermented
2.	Water Hyacinth. Grass (Durva)	0.750 0.750	1.500	21	0.056	Well Fermented
3.	Water Hyacinth. Water Lettuce	0.750 0.750	1.500	15	0.145	Best fermentation obtained
4.	Water Lettuce Grass (Durva)	0.750 0.750	1.500	21	0.475	Well Fermented
5.	Water Hyacinth	1.500	1.500	21	0.050	Well Fermented
6.	Water Lettuce	1.500	1.500	15	0.021	Well Fermented
7.	Grass (Durva)	1.500	1.500	30	0.770	Does not ferment well

Started on: 1979 Sept 1

SET NO. 7

Sl. No.	Ingredients	Wt. in kg.	Total Wt. in kg.	Duration of Fermentation Days	Dry Wt. (Sun Dried) in kg.	Remarks
1.	Water Hyacinth Water Lettuce Grass (Durva)	0.500 0.500 0.500	1.500	21	0.087	Grass not well fermented
2.	Water Hyacinth Grass (Durva)	0.750 0.750	1.500	21	0.131	Of the 8 samples, this ferments the best
3.	Water Hyacinth Water Lettuce	0.750 0.750	1.500	15	0.079	Well fermented
4.	Water Lettuce Grass (Durva)	0.750 0.750	1.500	21	0.194	Grass not well fermented
5.	Water Hyacinth	1.500	1.500	15	0.097	Well Fermented
6.	Water Lettuce	1.500	1.500	15	0.180	Well Fermented
7.	Grass (Durva)	1.500	1.500	21	0.117	Fermentation Incomplete
8.	Cow-dung + Grass (Durva)	0.750 0.750	1.500	15	0.178	Well fermented good cake obtained

Started On: 1979 Sept 10

SET NO. 8

1.	African Payal	5.000	5.000	20	0.850	Well Fermented
2.	African Payal Water Spinach	4.000 1.000	5.000	20	0.890	Well Fermented
3.	African Payal Water Spinach.	3.500 1.500	5.000	20	0.810	Well Fermented
4.	African Payal Water Spinach.	3.000 2.000	5.000	20	0.790	Well Fermented
5.	African Payal Water Spinach.	2.500 2.500	5.000	20	0.900	Well Fermented
6.	African Payal Water Spinach.	2.000 3.000	5.000	20	0.900	Well Fermented
7.	African Payal Water Spinach.	1.500 3.500	5.000	20	0.950	Well Fermented
8.	African Payal Water Spinach.	1.000 4.000	5.000	20	0.980	Well Fermented
9.	African Payal Water Spinach.	0.500 4.500	5.000	20	0.980	Well Fermented
10.	Water Spinach.	5.000	5.000	20	1.100	Well Fermented

Started on: 1979 Sept 20

SET NO. 9

1.	Water Hyacinth	5.000	5.000	19	0.578	Well Fermented
2.	Water Lettuce	5.000	5.000	18	0.480	Well Fermented
3.	African Payal	5.000	5.000	15	0.460	Well Fermented
4.	Duck Weed	5.000	5.000	10	0.210	Excellent fermentation
5.	Water Spinach	5.000	5.000	18	0.560	Excellent fermentation
6.	Ramban	5.000	5.000	23	1.100	Not well fermented
7.	Morning Glory	5.000	5.000	25	1.200	Not well fermented
8.	Paragrass	5.000	5.000	30	1.350	Does not become homogenous
9.	Purple Nut Sedge	5.000	5.000	30	1.300	Does not become homogenous mass
10.	Durva Grass	5.000	5.000	30	1.200	Does not become homogenous mass
11.	Leucaena	5.000	5.000	28	1.400	Somewhat fermented

Started on: 1979 Sept 21

SET NO. 10

Sl. No.	Ingredients	Wt. in kg.	Total Wt. in kg.	Duration of Fermentation Days	Dry Wt. (Sun Dried) in kg.	Remarks
1.	Heterogenous Mixture of Aquatic Weeds 1. Water Hyacinth 2. African Payal 3. Water Lettuce 4. Duck Weed 5. Water Spinach 6. Ramban	50.000	50.000	20	10.200	Nice fermentation
2.	Heterogenous Mixture of Land Weeds 1. Leucaena 2. Morning Glory 3. Paragrass 4. Purple Nut Sedge 5. Durva Grass	50.000	50.000	33	14.500	Fermentation is satisfactory. But water quantity after 15 days is to be doubled
3.	Mixture of Land and Aquatic Weeds	50.000	50.000	28	13.100	Nice Fermentation
4.	Mixture of Land Weeds + Cow Dung	49.000 1.000	50.000	25	12.800	Nice Fermentation
5.	Mixture of Aquatic Weeds + Cow Dung	49.000 1.000	50.000	14	9.100	Excellent Fermentation
6.	Mixture of Aquatic and Land Weeds + Cow Dung	49.000 1.000	50.000	20	12.100	Well fermented

OBSERVATIONS:

1. The fermentation can take place in transparent polyethylene bags.
2. The 1.5 kg, 5 kg and 50 kg of plant material on fresh weight basis required 0.5 lts, 2 lts and 10 lts of water initially and on every fourth day thereafter. Only in case of mixture of land weeds the volume of water added had to be doubled after the 15th day.
3. Water hyacinth, water lettuce, duck weed, african payal, water spinach, lucaena ferment well individually or in mixture.
4. When cattail, paragrass or durva grass were mixed with the above mentioned plants the fermentation process deteriorated and was incomplete in most of the cases.
5. Addition of cowdung improved the fermentation process in case of durva grass and probably will do so in all cases where lignin content is high.
6. Shredding made fermentation possible in case of cattail and its mixture with other aquatic plants.

Trials for use of the fermented mass as fuel:

The fermented mass was made into balls and cakes and dried. They are being used in the canteen of the Institute and by the family of two employees consisting of 15 persons for the last 1½ months. The reaction has been satisfactory, and the comments received were that they give more smoke in the initial stages but seemed to produce more heat than cowdung cakes.

Mass scale utilisation of the process has been started in 10 villages of Divi Taluka in Andhra Pradesh for production of bio-dung cakes recently under the initiative of Mr K C Shroff. By March, 1980 a full report on the experiments on a large scale will be available.

We feel that this is one of the simplest processes by which 'biodung' cake can be produced from any soft weed or plant material. By producing saleable and utilisable products, it will provide maximum motivation for eradication of water hyacinth and water lettuce the most nuisible aquatic weeds.

Trials for the fermented mass for use as biogas plant feed:

Trials were carried out in bench scale to determine if methane can be obtained from the fermented biomass. The trials were carried out with both fresh and dried fermented mass. In both the cases about 60% combustible gas (CH_4?) was obtained.

We could not carry out pilot plant scale and full scale trials due to circumstances beyond our control. It is our intention to carry out full scale trials with the help of a 1.70 m³/day biogas plant of the novel design developed by Dr A. K. N. Reddy, Convenor of ASTRA as a sponsored projeecct of Tata Energy Research Institute (2).

We consider the experiment with dry biodung for biogas production as very significant. If biogas can be obtained from the dried fermented mass in sufficient quantities then it would mean that the dried cakes can be manufactured in large quantities during the post monsoon period when the weeds are abundant and transported like coal to places where they are required particularly to the arid areas having little vegetation.

Use as Fertilizer:

The fermented bio-mass was also tried as a fertilizer for vegetable garden of C. C. Shroff Research Institute and the results obtained were far superior compared to controlled set of vegetables. However, quantification of this better yield is still under progress. This manure is far superior to cow (cattle) manure for the following reasons:

> A cow's digestive system—obviously—is designed to extract as many nutrients for the cow as possible from the mass of organic material which passes through it and is eventually ejected as manure.
>
> Whereas the plastic bag manure is a "digestive system", by contrast it turns everything that it contains (except for few gases which escape) directly into manure with no food value extracted.
>
> And the additional bonus for this work is: It's just one whole of a lot easier to make this artificial manure than it is to produce ordinary pit compost.

Use as a Compost:

Very recently trials have been also conducted successfully to use the fermented biomass as a compost for Paddy-straw Mushroom, *Volvariella volvacea* (hemmi variety).

The procedure followed was as follows:

Well fermented biodung obtained from water hyacinth and water lettuce in 20 days was used for the experiment of biogas.

Fresh biodung of 20 days without addition of water and sun-dried biodung with addition of water was allowed to digest in 10 litre bottle. This bottle was then connected to a measuring cylinder filled with saline water and the gas was collected by displacement.

In case of the fresh biodung, the optimum gas was collected in 30 days, and in the dried biodung the optimum was collected in 25 days. In case of biogas obtained from the fresh biodung 30 to 35 percent was CO_2. Rest of the gases were found to be combustible (CH_4?).

In case of biogas obtained from the dried biodung, 40 to 45 percent was CO_2. Rest of the gases were combustible.

Nevertheless, identification of CH_4 on gas liquid chromatography is not yet complete.

Biogas obtained from fresh and sun-dried bio-dung:

	Amount of gas collected	Amount of gas in litres per kg of bio-dung	Percentage of Composition	
			CO_2	*Rest of the gases (CH_4?)
Fresh bio-dung	(*a*) 1050 litres from 6 kg of bio-dung	175	30—35	65—70
	(*b*) 900 litres from 5 kg of bio-dung	180		
Sun dried bio-dung	(*a*) 1200 litres from 4 kg of bio-dung	300	40—45	55—60
	(*b*) 1100 litres from 4.5 kg of bio-dung	244		

*Rest of the gases are combustible. But identification of CH_4 using gas liquid chromatography is under process.

Note: 1 kg fresh cowdung = 45 lts. biogas.

Future Plans:

(i) To continue experiments with plant materials other than the ones cited in this paper.

(ii) To carry out pilot plant and full scale trials in Bombay, Andhra Pradesh, Kutch and Bengal.

(iii) To identify the microflora of the fermented mass.

(iv) To determine volume of biogas produced per unit weight of fermented mass.

(v) To determine C:N ratios of different mixes.

(vi) To analyse the biogas for CH_4, CO_2 and H_2S contents.

(vii) To determine the suitability of the process for disposal of poisonous and allergy-producing weeds.

REFERENCES:

1. Dycus Roy, July/August, 1978, "How to make cow manure without a cow". *The Mother Earth News*, pp. 28-29.

2. Reddy Amulya Kumar N., Prasad C. R., Rajabapaiah P., Sathyanarayan S. R. C. Sept. 1979, Studies in biogas technology. Part IV. A novel biogas plant incorporating a solar water heater and solar still, *The Indian Academy of Sciences, Proceedings C*, 2(3) p 387-393.

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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3/2

Abstracts of Selected Solar Energy Technology

Volume 3, Number 2, February 1981

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OFFICIAL NEWSLETTER OF THE UNITED NATIONS CONFERENCE
ON NEW AND RENEWABLE SOURCES OF ENERGY

THE UNITED NATIONS UNIVERSITY

UNITED NATIONS CONFERENCE ON
NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

Unless otherwise explicitly stated, the views expressed in the abstracts and articles contained herein are not necessarily those of the United Nations University.

ASSET gratefully acknowledges the abstracts provided from the computer files and/or documents of the following institutions (in alphabetical order):

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2-5-2 Nagata-cho, Chiyoda-ku, Tokyo 100, Japan

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Bombay House, 24 Homi Mody Street, Bombay 400 023, India

Technical Information Center (DOE), P.O. Box 62
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Recipients are encouraged to provide **ASSET** with copies of their publications concerning the technological and socio-economic aspects of solar, bioconversion and wind energy utilization for abstracting in future issues.

THE UNITED NATIONS UNIVERSITY
Printed in Japan 1981

INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy
  - B1 Radiation Measurement
  - B2 Photovoltaic Conversion
  - B3 Active Thermal Systems
  - B4 Passive Thermal Systems

C. Bioconversion Energy
  - C1 Biomass Production and Conversion
  - C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

057/81 ENERGY FOR WORLD AGRICULTURE. B.A. Stout. FAO Agricultural Series No. 7. Food and Agriculture Organization of the United Nations, Rome, Italy (1979).

This book provides a well documented assessment of present and future applications of energy in agriculture with emphasis on the future technological prospects for the use of renewable resources. Thus, energy in relation to the food system is put into perspective, and guidance is provided for the application of energy to agriculture for those concerned with increasing food supplies - especially for developing countries. Energy resources are examined and principles and efficiencies of various conversion processes are considered together with detailed descriptions of their application to agriculture and the total food system. A conceptual outline is given of the energy flow in the food system, and the energy requirements of each stage of food production, processing and delivery are considered. The implications, as far as energy is concerned, of providing an adequate diet for the expanding world population are discussed as are alternative energy sources for the future. 282 refs.

058/81 ENERGY DILEMMAS IN ASIA: THE NEEDS FOR RESEARCH AND DEVELOPMENT. R. Revelle. Science, vol. 209, p. 164-74 (1980).

Outside of China, the countries of southern and eastern Asia contain 30% of the world's population but only 2% of the known fossil-fuel resources. Economic growth has resulted in increasing imports of petroleum and petroleum products to these nations. Because of the tenfold rise in oil prices since 1972, several of these countries are faced with two dilemmas - one short range and one long range. Unless they can discover more fossil-fuel resources within their own borders, they must either incur dangerously growing foreign-exchange deficits or drastically slow economic growth. Research and development in energy production, conversion, and conservation should eventually allow local energy sources, of which the most promising is biomass energy, to be substituted for imported fuels. However, diverting scarce land and water to plantations of fast-growing trees or other kinds of biomass may seriously limit food production in these crowded countries.

059/81 ENERGY AND THE DEVELOPING COUNTRIES. P.D. Dunn (University of Reading, Reading (UK)). P. 621-41 of Aspects of Energy Conversion (Proceedings of a Summer School, held Oxford, UK, 14-25 July 1975). Pergamon Press, Elmsford, NY, USA (1976).

Complementary roles for the greater use of a small-scale rural-based power plant, used to assist development, are explained. Solar energy utilization and methane gas generation from waste are also discussed. 9 refs.

060/81 ENERGY ALTERNATIVES FOR THE YEAR 2000. M. Swiss. Energy International, vol. 16, no. 6, p. 22-4 (June 1979).

Remote villages in industrially developing countries that presently rely on oil for a substantial part of their energy supply could find that it would be more economical to introduce locally available renewable resources than to replace oil with another imported fuel. Two possibilities are wind and biomass energy. The author looks at some of the progress that has been made in the industrially developed world for exploiting these two energy sources. It is concluded that further development is needed in the microbial production of fuels from biomass before it will become economically feasible for areas of low agricultural self-sufficiency. Methane and ethanol production from petroleum sources are considered more viable at this time. Several large-scale off-shore wind projects are examined and compared with wind projects located on land sites.

061/81 GLOBAL ASPECTS OF SUNLIGHT AS A MAJOR ENERGY SOURCE. J.M. Weingart (Solar Energy Group, Energy and Environment Division, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (USA)). Energy, vol. 4, p. 775-98 (1979).

To achieve and sustain a decent livable world for all is a central goal for human society. While an abundant supply of energy is not in itself a determinant of such a world, it is nevertheless helpful. A careful inquiry suggests that sunlight could eventually be the primary, and even exclusive, source of heat, electricity and synthetic fuels for the entire world, continuously and eternally on a scale (upwards of 100 TW) generally regarded possible only with fusion or with fission via the fast breeder reactor. This could be achieved through a global network of solar-conversion facilities coupled with appropriate energy-transport and storage systems, and appears to be possible within acceptable constraints on energy-payback time, materials and water resources, capital investment, and available suitable land.

B. SOLAR ENERGY

062/81 SOME SOLAR ENERGY PROGRAMS IN THE UNITED NATIONS SYSTEM. B. Châtel (United Nations, New York, NY (USA)). Vol. 1, p. 26-30 of Sun: Mankind's Future Source of Energy. (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon Press, Elmsford, NY, USA (1978).

This report outlines recent activities in the United Nations System concerning solar energy applications for the benefit of developing countries. Summaries are provided of some of the main programmes undertaken in the field of solar energy by a number of agencies and bodies of the United Nations System.

063/81 SOLAR ENERGY: PAST AND PRESENT DEVELOPMENTS. T. Pytlinski. P. 611-22 of Proceedings of the Miami International Conference on Alternative Energy Sources (held Miami Beach, FL, USA, 5-7 Dec. 1977). University of Miami, Coral Gables, FL, USA.

A historical review of solar energy utilization is presented with consideration given to the work of Archimedes, Lavoisier (solar furnace), Mouchot (solar steam engine), Ericsson (Stirling-type solar engine) and Goddard (solar devices). Attention is also given to more recent achievements in solar energy devices, including the Odeillo solar furnace, the solar-irrigation plant in Willard, New Mexico, USA, and the solar power plant in Albuquerque, New Mexico, USA. 38 refs.

064/81 TEMPERATURE EFFECTS IN PHOTOELECTROCHEMICAL CELLS. P.V. Kamat, M.D. Karkhanavala and P.N. Moorthy (Chemistry Division, Bhabha Atomic Research Centre, Bombay (India)). Journal of Applied Physics, vol. 50, no. 6, p. 4228-30 (June 1979).

The performance of photo-electrochemical cells made of an n-type TiO_2 photo-anode and an O_2/OH^- redox electrolyte system have been studied at different temperatures. It has been found that when only the photo-anode compartment is heated, the open-circuit voltage decreases (approximately 2.0 $mV\,°K^{-1}$) and the short-circuit current increases (approximately 0.8 $mA\,m^{-2}\,°K^{-1}$); however, the power output shows a small increase, and a fall thereafter. The behaviour is similar to that of Schottky-barrier solar cells. When both of the electrode compartments are heated, the power output increases with increasing temperature (approximately 0.4 $mW\,m^{-2}\,°K^{-1}$) and this can be attributed to the enhancement of the rate of the electrochemical reaction at the counter electrode.

065/81 TECHNICAL AND ECONOMIC ASSESSMENT OF SOLAR POWERED WATER PUMPING FOR REMOTE AREAS. FINAL REPORT. (Bechtel National, Inc., San Francisco, CA (USA)). SAND-79-8187 (July 1979) 110p. NTIS. US$9.00.

The technology of solar-powered water pumping is reviewed. An overview of this technology and its economics is provided, based on a review and assessment of the open literature. It is shown that pumped water is used most extensively for irrigation and that new irrigation methods, such as the centre-pivot system, have significantly increased the water-pumping power demand in recent years. The coincidence of the peak irrigation season and peak seasonal insolation makes solar energy a good candidate to supplement or displace depletable energy sources currently used for water pumping. Solar-powered water-pumping demonstration systems utilize solar-thermal, photovoltaic and wind-powered energy conversion. The prime movers of these systems either drive the pumps directly or indirectly through electric-power generation. A comparative evaluation of these and other proposed solar energy concepts was conducted and resulted in the selection of a reference system comprising a number of individual parabolic dish collectors with integral Brayton-cycle engines. This reference system provided a basis for economic comparisons with a typical conventional electric-pumping system. It was determined that the cost of power from the reference solar concept will probably not break even with present-day utility-powered pumping systems until at least the turn of the century.

066/81 DEVICE AT HEATING A LIQUID BY SOLAR ENERGY. L.A. Bergkvist. US Patent 4,167,937, (18 Sept. 1979). 6p.

A solar-heating device is provided for heating a liquid used in the device as the refractive medium. A lens and a heat-absorbing member carry the liquid and are connected together so that the liquid can be communicated there-between. The lens concentrates the solar energy on the heat-absorbing member when the lens is full of the liquid, thereby increasing the temperature of the liquid in the heat-absorbing member. In a failure condition, where the liquid is drained from the heat-absorbing member, the liquid also is drained from the lens, decreasing the refraction of the solar energy focused by the lens on the heat-absorbing member and thereby decreasing the temperature of the heat-absorbing member to avoid a fire.

067/81 TECHNIQUES OF SELECTED COATING. P.K.C. Pillai and P.K. Saxena (Indian Institute of Technology, New Delhi (India)). Vol. 2, p. 1085-6 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.).

Pergamon Press, Elmsford, NY, USA (1978).

Methods of electro-deposition of selective coatings on an aluminium substrate are described. The selective thin coating is basically a two-layered deposition of successive bright and black metal on an aluminium substrate. The main emphasis has been laid upon devising coating techniques which can be successfully used in the construction of a collector system with sufficiently high efficiency and considerable cost economy. 9 refs.

068/81 EXPERIMENTAL METHODS FOR THE PREPARATION OF SELECTIVELY ABSORBING TEXTURED SURFACES FOR PHOTOTHERMAL SOLAR CONVERSION. G. Pellegrini (Materials Science Division, Ispra Establishment, Joint Research Centre, Commission of the European Communities, 21020 Ispra (Varese) (Italy)). Solar Energy Materials, vol. 3, p. 391-404 (1980).

Metal surfaces with a particulate micro-structure (dendritic, porous or granular) on the same scale as the wavelength of the incident radiation reveal both spectral and directional selectivity. The selective properties of such surfaces can be explained by a geometrical mechanism based on multiple reflections on the facets of adjacent individual components and are not very sensitive to environmentally induced structural modifications, which are generally responsible for the rapid deterioration of the optical properties in conventional selective coatings. Therefore, textured metal surfaces can be considered as valuable candidates for photothermal conversion on a larger scale, provided that simple and cheap methods for the preparation and control of the surface micro-structure are made available. In this paper various possible preparation methods are presented and compared with a view to exploitation on a larger scale. The methods are based on already proven mechanisms, such as liquid-solid transformations, depositions from a vapour phase and chemical reactions in oxidizing and corrosive environments.

069/81 SOLAR DISTILLATION AND ITS PROSPECTS (TAIYŌNETSU-JYŌRYŪ TO SONO SHŌRAI). E.A. Delyannis and A.A. Delyannis (Technical University, Athens (Greece)). Solar Energy, vol. 6, no. 4, p. 35-42 (1980). In Japanese.

The theory of solar distillation is given with emphasis on its advantages and its capabilities. Various models and structures of solar stills are described with special attention given to those developed and presently used in Greece (glass-covered solar stills). Six solar-distillation plants are now in operation in six different locations. It is pointed out that the amount of distilled water can be increased throughout the year by using a combined solar-distillation and rain-collection system. Reference is made to the improvement of various types of solar-distillation plants in order to overcome the disadvantages of a storage-type solar still which is used for distillation purposes only. For large-scale operation, a desalination plant using solar energy as the input energy is recommended. In this connexion, experiments carried out at a pilot plant, proposed by Tleimat and Howe, and a joint development programme between Mexico and the Fed. Rep. of Germany, focussing on experiments on the use of solar energy for multiple-layer flash desalination plants, are introduced. Other prospects for using solar energy for desalination include a combination of the use of solar energy and desalination without using a solar-distillation system and the application of reverse-osmotic effects using wind or solar energy. Some economic aspects of solar distillation are discussed.

070/81 DESIGN AND TEST OF NON EVACUATED SOLAR COLLECTORS WITH COMPOUND PARABOLIC CONCENTRATORS. A. Rabl, J. O'Gallagher and R. Winston (Enrico Fermi Institute, University of Chicago, Chicago IL (USA)). EFI-79-42 (July 1979) 60p. NTIS. US$7.75.

The intermediate range of concentration ratios (1.5X - 10X), which can be achieved with compound parabolic concentrators (CPC) without diurnal tracking, provides both economic and thermal advantages for solar-collector design, even when used with non-evacuated absorbers. The present paper summarizes more than 3 years of research on non-evacuated CPCs and reviews measured performance data and critical design considerations. Concentrations in the upper portions of the practical range (e.g. 6X) can provide good efficiency (40 to 50%) in the 100 to 160 °C temperature range with relatively frequent tilt adjustments (12 to 20 times per year). At lower concentrations (e.g. 3X), performance will still be substantially better than that for a double-glazed flat-plate collector above 70 °C and competitive below, while requiring only semi-annual adjustments for year-round operation. In both cases the cost savings associated with inexpensive reflectors, and the optimal coupling to smaller, simple inexpensive absorbers (e.g. tubes, fins, etc.) can be as important an advantage as the improved thermal performance.

071/81 SOLAR SPACE HEATING AND AIR CONDITIONING, VOLUME 2, 1976-AUGUST 1977 (CITATIONS FROM THE NTIS DATA BASE). A.S. Hundemann (National Technical Information Service, Springfield, VA (USA)). NTIS/PS-78-1014 (Sept. 1978) 247p. NTIS.

Design, technical feasibility, performance, and economic factors pertaining to solar heating and cooling of buildings are discussed. Commercial buildings, schools and residential buildings are covered, with emphasis on the assessment of solar-heating and -cooling systems for residential buildings. Included are a few abstracts of reports on: solar energy as a national-energy resource; solar energy research programme alternatives; and social, environmental, and institutional factors affecting the feasibility of using solar energy for the heating and cooling of buildings. This updated bibliography contains 241 abstracts, none of which are new entries to the previous edition.

B1. RADIATION MEASUREMENT

072/81 SOLAR RADIATION INSTRUMENTS. K.L. Coulson (Mauna Loa Observatory, Hawaii (USA)) and Y. Howell. Sunworld, vol. 4, p. 87-94 (1980).

This article provides a summary of the types of instruments used for measuring solar radiation including pyrheliometers, pyranometers and duration-of-sunshine instruments. A description of the sensor for each instrument and its use and performance characteristics are included with an illustration. Each instrument is rated according to the classification of the Commission for Instruments and Methods of Observation of the World Meteorological Organization.

B2. PHOTOVOLTAIC CONVERSION

073/81 PHOTOVOLTAICS: A REVIEW. G.C. Jain and B.K. Das (National Physical Laboratory, New Delhi (India)). P. 1.11-1.36 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Research on single-crystal silicon solar cells, tracking and non-tracking concentrating systems, performance of solar cells at different temperatures, and the establishment of a test facility are described.

074/81 NOVEL CONCENTRATOR PHOTOVOLTAIC CONVERTER SYSTEM DEVELOPMENT. FINAL REPORT, JANUARY 24-AUGUST 30, 1979. S.M. Bedair, J.R. Hauser and M.F. Lamorte (Research Triangle Institute, Research Triangle Park, NC (USA)). SAND-80-7004 (Mar. 1980) 62p. NTIS.

The long-range objective of this work is to develop, synthesize, and evaluate a novel cascade solar cell having an AM1 conversion efficiency of 30% or greater and which is capable of operating at both high-illumination levels and elevated temperatures. The major emphasis has been on a study of several material systems for their potential use in the cascade solar cell. Studies have included basic properties of different materials as well as p-n junction analysis for the top cell, tunnel junction, and bottom cell. While junctions appropriate to each individual part of the cascade cell have been demonstrated, problems still remain in fabricating a high-efficiency cascade solar cell because of material and growth problems with the semi-conductor layers which have optimum bandgaps.

075/81 GaAs-GaAlAs SOLAR CELLS. G.S. Kamath, and C.I. Anderson (to Hughes Aircraft Co.). US Patent 4,163,987 (7 Aug. 1979). File date: 2 May 1977. 6p.

An improved III-V compound solar-cell structure and fabrication process are described wherein a p-type layer of gallium aluminium arsenide is epitaxially grown on an n-type gallium arsenide substrate to form a p-type region and a p-n junction in the substrate. Controlled amounts of beryllium are introduced into both the epitaxial layer and the substrate, either during epitaxial growth or by using beryllium ion-implantation techniques subsequent to the p-type epitaxial growth step. The homojunction-heterostructure device, thus formed, exhibits improved power-conversion efficiencies in excess of 17%.

076/81 $CuGa_xIn_{1-x}Se_2$ THIN FILMS FOR SOLAR CELLS PREPARED BY FLASH-EVAPORATION. N. Romeo, V. Canevari, G. Sberveglieri (Instituto di Fisica CNR, GNSM e PFE-SPES, Parma (Italy)), O. Vigil and L. Zanotti. Solar Energy Materials, vol. 3, p. 367-70 (1980).

$CuGa_xIn_{1-x}Se_2$ thin films were prepared by flash evaporation. The stoichiometry of such films is identical to the polycrystalline powder from which the films are made, and the forbidden gaps obtained by optical-absorption measurements are identical to that of single crystals with the same composition. The films exhibit a columnar structure and have a crystalline-grain dimension of 0.3 μm when deposited on mica substrates. They are p-type with a resistivity of 1-100 Ωcm and with a hole mobility of 1-2 $cm^2 V^{-1} s^{-1}$. The above characteristics indicate that flash evaporation is a suitable technique for preparing $CuGa_xIn_{1-x}Se_2$ films for hetero-junction solar cells.

077/81 LARGE-AREA HIGH-EFFICIENCY (AlGa)As-GaAs SOLAR CELLS. G.S. Kamath, J. Ewan and R.C. Knechtli (Hughes Research Laboratory, Malibu, CA (USA)). Institute of Electrical and Electronics Engineers Transactions on Electron Devices, ED-24, no. 4, p. 473-5 (Apr. 1977).

An improved technique for making large-area high-efficiency (AlGa)As-GaAs solar cells is described. This includes a modified infinite-melt liquid-phase epitaxial process for growing the desired (AlGa)As-GaAs and GaAs layers. Representative solar cells fabricated in this manner are described. Performance with an AMO efficiency in excess of 16% is shown for cells of a 4-cm^2 area. Means are also shown for increasing this efficiency to about 18%. 11 refs.

078/81 THE DEVELOPMENT OF A HIGH-EFFICIENCY SILICON BSF TYPE SOLAR CELL. (KŌKŌRITSU SHIRIKON BSF-GATA TAIYŌDENCHI NO KAIHATSU). A. Usami and M. Sonobe (Nagoya Technical University, Nagoya (Japan)). Denshi Tsūshin Gakkai Gijutsu Kenkyū Hōkoku (Technical Report of the Electronics Communication Society), vol. 78, no. 215, p. 15-22 (1979). In Japanese.

A prototype model of an Si solar cell of the BSF type (with a thin p^+ layer on the reverse side - n^+ / pp^+ BSF type) was constructed with the aim to optimize each parameter. The special I-V characteristics, spectrum characteristics and the carrier-diffusion length were measured to help find ways to improve the open-circuit voltage, short-circuit current and conversion efficiency. The efficiency obtained was 14.1% when an Al-alloy element with a 5-Ωcm Si base plate was used; a 613-mV open-circuit voltage was obtained with a 1-Ωcm base plate. 20 refs.

079/81 THE APPLICATION OF SOLAR CELLS. D. Follea (Asian Institute of Technology, P.O. Box 2754, Bangkok (Thailand)). Renewable Energy Review Journal, vol. 2, no. 1, p. 1-19 (July 1980).

This article presents three major terrestrial applications of the photovoltaic conversion of solar energy: water-pumping and irrigation, radio relays and navigational beacon lights, and rural electrification. For these three fields, the state-of-the-art of the applied techniques is given. As for rural electrification, a method of predicting the payback time of photovoltaic systems in a dynamic economical environment is developed, and a village in Africa is given as an example. 5 refs.

B3. ACTIVE THERMAL SYSTEMS

080/81 THERMAL APPLICATION OF SOLAR ENERGY. B.R. Best, M. Juarez, B.E. Mayer, Q.G. Olalde and F.I. Pilatowsky. P. 608-13 of Proceedings of the Fourth Inter-American Conference on Materials Technology (held Caracas, Venezuela, 29 June 1975). (1975). In Spanish.

In order to participate in the economic development of arid zones, which cover 65% of Mexican territory, a research programme on solar energy applications has been initiated. The efficiency of flat-plate collectors has been analysed in Mexico City together with the application of these collectors for water heating in housing complexes. In order to examine the absorptivity and emissivity of several coatings, a systematic study of the daily heating and night cooling of treated plates has started. An apparatus for refrigeration by intermittent absorption has also been built. This equipment works with water and ammonia and can be coupled to a flat-plate collector. Experimental results are reported.

081/81 SOLAR ENERGY SYSTEMS FOR CONTINUOUS PROCESS. S.C. Bose (National Industries Development Corporation, Chanakya Bhavan, Vinay Marg, New Delhi 110021 (India)). National Industries Development Corporation, New Delhi, India. 23p.

This paper discusses the economic aspects of technically viable solar energy systems to be used in the continuous-processing industry. The industries for which they (hot-air and -water systems) are likely to be used are: bulk processing of agricultural products; drying of parboiled paddy, bagasse, cardboard, plywood and pharmaceutical products; curing of tobacco, coffee and pepper; and the processing of tea. The main emphasis is on the evaluation of economically attractive solar energy systems. 4 refs.

082/81 INFLATED FLEXIBLE SOLAR COLLECTORS. US Patent 4,151,830 (1 May 1979). 6p.

An inflatable collector for solar energy is presented in which superposed layers of a plastic sheet material are heat sealed to one another to provide a pair of layers, forming an absorber unit. The upper layer is pigmented to absorb solar radiation and the pair of layers are sealed to one another in a pattern which provides a continuous elongated path. Fluid is supplied to one end of this elongated path, and at least one transparent layer overlies the pair of layers to provide a return space. Valves interconnect the end of the elongated path which is remote from the fluid supply end with the return space so that fluid heated in the elongated path is further heated in the return space before being withdrawn from the collector.

083/81 APPLICATION OF SOLAR FLAT PLATE COLLECTOR IN TURKEY. B. Kilkis (Middle East Technical University, Ankara (Turkey)). P. 88-96 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

Studies have shown that efficient application periods for flat-plate solar water heaters vary between 12 and 7 months in Turkey. Flat-plate collectors with a fixed inclination have been developed by various institutes and private establishments and are now being produced. The most common types use 1-m^2 and 2-m^2 double glass (3-mm thick) plates. The efficiency is above 44% for moderate climates.

This paper analyses the characteristics and operation of flat-plate collectors being produced in Turkey. It gives some details and makes comparisons with foreign flat-plate collectors.

084/81 LOW-TEMPERATURE THERMAL SOLAR MOTOR. G.Y. Umarov, A.K. Alimov and N.F. Ovechkin (Physical-Technical Institute, Tashkent, Uzbek SSR (USSR)). Applied Solar Energy, vol. 14, no. 6, p. 56-7 (1978) [English translation of Гелиотехника, vol. 14, no. 6, p. 67-8 (1978)].

A simple solar motor in the form of a wheel with mobile loads and operating on hot water is described. The working material is an expanding low boiling-point liquid.

085/81 USE OF A HONEYCOMB AS SOLAR RADIATION ABSORBER AND HEAT EXCHANGER IN AN AIR-TYPE SOLAR COLLECTOR. J.T. Pytlinski and R.E. Hightower (Kansas State University, Manhattan, KS (USA)). Vol. 1, p. 191-8 of Alternative Energy Sources (Proceedings of the Alternative Energy Sources Symposium, held Miami Beach, FL, USA, 5 Dec. 1977). T.N. Veziroglu (ed.), Hemisphere Publishing Corp., Washington, DC, USA (1978).

A honeycomb collector of an innovative design was built and tested. The main element of the collector is a honeycomb structure with a vertical wall thickness of 0.09 mm and 11 hexagonal holes per square cm, creating a heat-transfer area of eighty one, which compares to a ratio of one for a flat-plate collector of the same external dimensions. The internal section of the collector is built in such a way so that the painted flat-black honeycomb serves as the solar radiation-absorbing element, and at the same time serves as the heat exchanger for the air passing through it. Due to the direction of mechanical stresses, the honeycomb element is especially suitable for forming an integral part of a roof structure. The design of the collector, and its step-by-step construction, is presented in detail. The testing results of the collector show that output air temperatures in the range of 93 °C and efficiencies in the range of 80% could be obtained.

086/81 HONEYCOMB HEAT TRAP: ITS APPLICATION IN FLAT PLATE SOLAR COLLECTORS. D. Hart (Watershed Energy Systems Ltd., Toronto, Ontario, (Canada)). Vol. 2, p. 1.1.7.1-1.1.7.10 of Renewable Alternatives (Proceedings of the Fourth Annual Conference of the Solar Energy Society of Canada, Inc., held London, Canada, 20 Aug. 1978). Solar Energy Society of Canada Inc., Winnipeg, Manitoba, Canada (1978).

A collector has been developed incorporating a heat trap constructed of teflon film, using design parameters developed at the University of Waterloo. Some properties of the heat trap are discussed, and test results from the Ontario Research Foundation are presented which substantiate the low cover losses predicted by theory.

087/81 USE OF SOLAR RADIATION FOR CREATING COMFORTABLE TEMPERATURE CONDITIONS IN TURKMENIAN SSR. V.A. Baum and A. Kakabayev (Physical and Technical Institute, Ashkhabad, Turkmen SSR (USSR)). Vol. 3, p. 1556-60 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon Press, Elmsford, NY, USA (1978).

During the last eight years, three absorption solar-cooling units have been constructed and tested. The first two experimental units were rated at 6000 kcal/h. The third device, with a cooling capability of 35000 kcal/h, has been in use during the hot season for four years for cooling the rooms of a three-story building with a total area of 500 m^2. A review is given.

B4. Passive Thermal Systems

088/81 INTRODUCING SOLAR POWERED SOLVENT EXTRACTION OF COCONUT OIL IN PANJANG REJO, A VILLAGE IN CENTRAL JAVA, INDONESIA. M.S.A. Sastroamidjojo (Solar Energy Research Centre, Gadjah Mada University, Yogyakarta (Indonesia)). Renewable Energy Review Journal, vol. 2, no. 1, p. 35-45 (July 1980).

Oil-extraction from peanuts, coconuts and oil-containing seeds is generally done by pressing. Presscakes often contain up to 15% residual oil, and since for lifestock admixtures 5% oil content is ample, about 10% could still be extracted if an economic method could be found. Solvent extraction of presscakes containing residual oil has been attempted using a Soxhlet device, modified for solar energy use. Solar energy falling on a blackened metal box containing the solvent evaporates the solvent. At the upper part of the apparatus condensation takes place and the condensate streams down a column filled with the presscake containing residual oil. The oil-solvent mixture collects in the metal box in which the volatile component is again separated by solar energy, leaving a progressively enriched mixture in the metal box. The final product is bled off after standing overnight. The process is primarily intended for cottage industries in rural surroundings, picking up where the oil factories leave off. However, there is, a priori, no reason why the process cannot be scaled up. The laboratory experiment was transferred to a village at the actual site of coconut-oil production. It was found in this particular case that the solar energy device was accepted on the bases of added income because of fuel saved. The fuel saved, in this case charcoal, which was a by-product of the coconut-oil production process, could be sold at a profit in a nearby town. From a social and economic point of view careful consideration has to be given to the fact that introduction of a new technology, in this case solar technology, can reduce man-power and is, therefore, unacceptable in the village context as a whole. 3 refs.

089/81 INVESTIGATION ON SEA WATER DESALINATION PLANTS IN SPAIN. S. Muro, R. Sterner and J. Ugarte (Junta Energia Nuclear, Madrid (Spain)). Desalination, vol. 28, p. 109-16. (1978).

A description of various experimental installations at La Moncloa in Madrid, Spain, are presented. These include multi-flash, vapour compression, reverse osmosis, electrodialysis and solar distillation projects. Also described are pilot projects for multi-flash and vapour-compression distillation located in Lanzarote, Canary Islands. Computer programmes for these systems are also given.

090/81 STUDY OF REGENERATIVE INCLINED-STEPPED SOLAR STILL. R.A. Akhtamov, B.M. Achilov, O.S. Kamilov and S. Kakharov (Bukhara Pedagogical Institute, Moscow (USSR)). Applied Solar Energy, vol. 14, no. 4, p. 41-4 (1978) [English translation of Гелиотехника, vol. 14, no. 4, p. 51-5 (1978)].

The results of regenerative solar still (RSS) experiments at the Bukhar State Pedagogical Institute solar test station are examined. The RSS efficiency is considerably higher in the second half of the day. This is explained by the fact that with an increase in the still productivity, the amount of heat absorbed by the discharged water also increases.

091/81 SOLAR POND CONCEPTS: OLD AND NEW. Solar Energy Research Institute, Golden, CO (USA)). P. 7 of Proceedings of the Fourteenth Intersociety Energy Conversion Conference (held Boston, MA, USA, 5 Aug. 1979). SERI/TP-35-208 (1979). NTIS. US$6.50.

Different types of solar ponds have been considered from the early 1900's to the present. Some ponds use salt to create a non-convective medium. Shallow solar ponds were investigated by Shuman and Willsie in 1906 and 1907 and are currently being studied by Lawrence Livermore Laboratories, CA, USA. Swedish investigators are studying a combination of solar collectors and water storage in a pond-cover configuration. In addition, there are thermo-clines created in large bodies of water, as in large reservoirs. This paper surveys the various types of solar ponds, classifies and models them, and then tries to combine the best of the ideas to synthesize new concepts. It presents a new solar-pond concept which combines the good features of convective and non-convective (salty) ponds.

092/81 MODEL STRATIFIED LAYER SOLAR POND WITH ENHANCED HEAT STORAGE. E.S. Wilkins and K.L. Pinder (University of British Columbia, Vancouver BC (Canada)). P. 1.3.2.1-1.3.2.9 of Proceedings of the Fourth Annual Conference of the Solar Energy Society of Canada (held London, Canada, 20 Aug. 1978). Solar Energy Society of Canada, P.O. Box 2220, Station A, London, Ontario, Canada.

The heat storage capacity of a small (65 x 65 x 25 cm) stratified-layer solar pond was enhanced by placing black plastic containers filled with solid inorganic hydrates on the bottom of the pond. Two hydrates were tested: sodium sulfate decahydrate and sodium dibasic-phosphate heptahydrate. Sodium sulfate decahydrate did not reform on cooling, but the phosphate hydrate was followed through many cycles. Thus, water circulating under the bottom partition in the solar pond could be used to recover this stored heat when needed.

093/81 SOLAR ENERGY ENTRAPMENTS FOR EARLY SEASON VEGETABLE PRODUCTION IN COLD REGIONS. J. Maghsood (University of Tehran, Karaj (Iran)). Vol. 3, p. 1879-83 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon Press, Elmsford, NY, USA (1978).

Work done to increase the outdoor-growing season in cold regions is discussed. The various types of crop-starting tunnels used in this study were the semi-circular growth tunnel, the Cornell tunnel (insulation in the inclined north wall), and the unheated growth chamber. The purpose of utilizing these tunnels was to increase the soil and air temperature for early season crop starting and growing. A combination of solar and either fuel or electrical energy was used for heating the tunnels. 4 refs.

094/81 PERFORMANCE OF A FLAT PLATE COLLECTOR FOR SOLAR COOKER. R.K. Rajput (Thapar Polytechnic, Patiala (India)) and G. Singh. P. 57-61 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

A flat-plate collector (1.25 m x 0.8 m) with aluminium sheet, serpentine copper tube and two glass covers has been designed, fabricated and then used with a conventional cooker to cook vegetables, cereal and mutton. The performance has been found quite satisfactory during the hot months. Although the time required for cooking these items is longer than cooking with gas, it is quite reasonable. Making tea with this system is no problem, and with a little modification coffee can also be prepared by a steaming process.

095/81 CONCAVE MIRROR SOLAR COOKER PART I (ĀOMIÀN BŌLI TAÌYÁNG ZÀODE SHÈJÌYǓ ZHÌZUÒ (SHÀNG)). Xú Shàomó and Xiāo Jiànqiú. Taìyángnéng, no. 2, p. 3-5 (1980). In Chinese.

This article describes the construction and operation of solar cookers that have been developed in China.

C. BIOCONVERSION ENERGY

096/81 BIOLOGICAL SOLAR ENERGY CONVERSION FOR FUELS. D.O. Hall (University of London, London, (UK)). Nature, vol. 278, p. 114-7 (8 Mar. 1979).

The availability of biomass and the need to efficiently develop its potential as a future energy source are discussed. The present research and development programmes on biomass in the USA, Canada, New Zealand, Philippines, Brazil, Sahel Region, India and China are discussed.

097/81 BIOLOGICAL PRODUCTION OF LIQUID FUELS FROM BIOMASS. SUMMARY REPORT. A.E. Humphrey (University of Pennsylvania, Philadelphia, PA (USA)) and E.J. Nolan. P. 581-7 of Proceedings of the Third Annual Biomass Energy Systems Conference (held Golden, CO, USA, 5 June 1979). SERI/TP-33-285 (Oct. 1979). NTIS.

This summary describes past, present, and proposed technologies for the biological production of liquid fuels and chemical feedstocks from biomass raw materials and to assess their potential for contributing to the national energy supply for the USA. The raw materials of interest can be grouped into four categories: (1) cereal grain starches, (2) sugar from cane and other similar agricultural crops, (3) cellulose from agricultural residues and municipal wastes, and (4) wood. The fuel under consideration is ethanol derived by fermentation processes. The summary comprises three major considerations: (1) economic analysis of existing process technologies and estimation of alcohol production costs of these processes translated into mid-1978 costs; (2) comparison of processes based on present and envisioned technological developments; and (3) technological challenges and breakthroughs needed to make the production of alcohol from biomass economically and energetically attractive.

C1. BIOMASS PRODUCTION AND CONVERSION

098/81 THE AMAZING IPIL-IPIL TREE. M.P. Chanco (Science News Service, P.O. Box 1365, Manila (Philippines)). Appropriate Technology, vol. 6, no. 2, p. 14-5 (1979).

The giant ipil-ipil tree (*Leucaena leuephala*) and its utilization in an energy-plant project in the Philippines are described. This project involves the use of trees as a direct field source for steam-powered electric generators. This tree reaches 12 m or more within 3 years and can reach a diameter of 63 cm in 2.5 years. In addition, the potential exists for using it as a source of methanol, which is estimated to cost US$0.05 per liter. Finally, the production of producer gas is also considered. Some information is also given about cultivation requirements and techniques.

099/81 OIL PLANTS - PRESENT AND FUTURE (SEKIYU SHOKUBUTSU NO GENJYŌ TO SHŌRAI). H. Nishimura (Faculty of Agriculture, Hokkaido University, Sapporo (Japan)). Solar Energy, vol. 6, no. 23, p. 24-34 (1980). In Japanese.

The concept of oil plants or 'gasoline trees' first introduced by M. Calvin for plants that can yield substances containing a high heating value, e.g. turpentine and other hydrocarbon compounds, is further detailed. Some basic requirements for 'gasoline trees' are given: these plants (or trees) should be fast growing and highly efficient in absorbing solar energy and producing many energy-containing components, as well as substances which would help lower the costs of cultivation and extraction; they should be cultivated even where no food crops are grown; and they should not contain any substance toxic to humans or livestock. At present, *Hevea braziliensis*, *Euphorbia* and *Eucalyptus* are considered suitable to meet the above requirements. Among others, however, the author recommends the use of *Eucalyptus* as the ideal kind as 'gasoline tree'. The results of experiments using each species are reported. Further studies on the integration of all the possibilities of this species are required in order to realize the maximum use as biomass energy sources, e.g. a study of waste products (cellulose and lignin), of the practical use of microbial wastes, and of the characteristics of the useful hydrocarbon-containing substance.

100/81 ENERGY PLANTATION FOR COROMANDEL LITTORAL. C.V. Seshadri and G. Venkataramani (Shri A.M.M. Murugappa Chettiar Research Centre, Madras (India)). P. 36-40 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

The advantages of plant matter for use in power generation are reviewed. Casuarina is suggested as an energy crop and sample calculations are shown.

101/81 PRODUCTION COST ANALYSIS OF Euphorbia lathyris. FINAL REPORT. D.A. Mendel, F.A. Schooley and R.L. Dickenson (SRI International, Menlo Park, CA (USA)). SRI-P-7877 (Aug. 1979) 32p. NTIS.

The purpose of SRI's study was to estimate the costs of producing Euphorbia in commercial quantities in five regions of the USA, which include both irrigated and non-irrigated areas. The study assumed that a uniform crop yield could be achieved in the five regions by varying the quantities of production inputs. Therefore, the production costs estimates, which are based on fourth quarter 1978 dollars, include both fixed and variable costs for each region. Doane's Machinery Custom Rates for 1978 were used to estimate all variable costs except materials, which were estimated separately. Custom rates are determined by members of the Doane Countywide Farm Panel, a group of farmers specifically selected to represent the various sizes and types of commercial farms found throughout the country. The rates reported are the most recent rates the panel members had either paid, charged, or known for certain a second party had paid or charged. Custom rates for any particular operation include equipment operating costs (fuel, lubrication, and repairs), equipment ownership costs (depreciation, taxes, interest), as well as a labour charge for the operator. Custom rates are regionally specific and thereby assist the accuracy of this analysis. Fixed costs include land, management, and transportation of the plant material to a conversion facility. When appropriate, fixed costs were regionally specific. Changes in total production costs over future time periods were not addressed. The total estimated production costs of Euphorbia in each region were compared with production costs for corn and alfalfa in the same regions. Finally, the effects on yield and costs of changes in the production inputs were estimated.

C2. BIOGAS PRODUCTION AND UTILIZATION

102/81 ANAEROBIC DIGESTION-OPTIMIZATION OF ENERGY SOURCE FROM WASTES. B. Volesky. Vol. 1, p. 365-72 of Proceedings of the International Conference on Water Pollution Control in Developing Countries (1978).

The satisfactory use of anaerobic digestion to purify wastes (produced not only from households and agricultural activity, but also from industrial operations) will help in the production of efficient fuel-gas mixtures which could alleviate energy shortages. The methods are examined by assessing efficiencies and operating parameters. This complex micro-biological process is explained in terms of biochemistry, microbiology and mechanics. This leads to an understanding of new types of reactors and their dynamics, which should enable the optimization of the digestion process.

103/81 ANAEROBIC DIGESTION OF GLUCOSE WITH SEPARATED ACID PRODUCTION AND METHANE FORMATION. A. Cohen, R.J. Zoetemeyer, A. Van Deursen and J.G. Van Andel (Laboratorium voor Microbiologie, Universiteit van Amsterdam, Plantage Muidergracht 14, Amsterdam (Netherlands)). Water Research, vol. 13, p. 571-80 (1979).

In a two-phase anaerobic-digestion system, with separate reactors for the acidification and methane fermentation phases, the glucose of a 1% glucose solution was almost completely converted into biomass and gases. The acid reactor was operated at 30 °C and a pH of 6.0, with a retention time of 10 h. The main products of the acid-forming phase were hydrogen, carbon dioxide, butyrate and acetate. On a molar base, these products represented over 96% of all products formed. On average, 12% of the COD content of the influent was evolved as hydrogen. The effluent of the first reactor was pumped to the methane reactor after passing through a storage vessel. The methane reactor was operated at 30 °C, pH 7.8 and a retention time of 100 h. Approximately 98% of the organic substances fed to this reactor were converted to methane, carbon dioxide and biomass. About 11% of the glucose fed to the digesting system was converted to bacterial mass.

104/81 PRODUCING METHANE GAS FROM SWINE MANURE IN A PILOT-SIZE DIGESTER. J.R. Fischer, E.L. Iannotti, J.H. Porter and A. Garcia. Paper presented at the American Society of Agricultural Engineers Mid-Central Region Meeting (held St. Joseph, MO, USA, 25 Mar. 1977). American Society of Agricultural Engineers (St. Joseph, MI, USA). CONF-7703133-1 (1977). 14p.

A 0.42-m^3 digester was operated for one year at a loading rate of 4-g volatile solids/liter/day. Gas production was 2.2 m^3 of gas per m^3 of digester liquid. The gas composition was 59% methane and 39% carbon dioxide. 52 and 61% of the total and volatile solids were destroyed, respectively. Ammonia-nitrogen concentration in the digester was approximately 3,000 mg/liter.

105/81 ECONOMIC AND KINETIC STUDIES OF THE PRODUCTION OF CHEMICALS AND FARM ENERGY BY FERMENTATION OF BIOMASS. J.L. Gaddy (University of Missouri, Rolla, MO (USA)). COO-4755-T1 (1979) 8p. NTIS. US$6.50.

A farm energy system has been constructed in Drury, Missouri, USA. The purpose of this

UNCNRSE

CONFERENCE NEWS 4

MESSAGE FROM THE NEW SECRETARY-GENERAL, ENRIQUE V. IGLESIAS

Scanning through history, few topics have attracted the attention of humanity as much as has energy. Energy - a fundamental issue to all people - permeates the fabric of human life with impact on world politics, on international economics and on national development strategies. In recent years, energy has acquired significant importance due to what has been called, with some ambiguity, the world energy crisis. Three important elements characterize this crisis and situate the problem in its correct perspective.

First, at the beginning of the 1970s, it became apparent that fossil fuels, which have been the basis of the energy balance of the modern world, will in the not too distant future be depleted. For the first time, the rate of reserve discoveries and the rate of consumption growth became inverted providing humankind with a realistic perspective based on scientific assessments that depletion could take place during the next generation. This fact drives home to humanity an urgency of attention to energy that has never been felt before.

The second element of this crisis comes from the fact that for the first time in history, an energy transition will be accompanied by higher economic costs. Until recently, people had lived through a period of cheap energy and depressed oil prices. From now on, energy will be available only at higher prices, setting a new challenge of unknown proportions.

Lastly, the energy crisis has affected humanity in a very unhomogeneous manner. The crisis, affecting both industrialized and developing nations, has had a very special impact on the developing countries. These countries will have to go through their process of economic development and modernization with much higher energy prices than those paid by the industrialized countries. This undoubtedly presents the international community with a problem of equity and solidarity which should stimulate international co-operation.

These factors which are behind the so-called energy crisis have produced reactions at the levels of government, of scientific organizations, and of the international community. The United Nations, whose raison d'être concerns international co-operation in the search for solutions to common problems of humanity, is in a unique position to discuss and initiate activities in the energy field. This is evidenced by the rapid acceleration of energy research and implementation programmes carried out by the United Nations family, including the international financial institutions such as the World Bank and the International Monetary Fund.

As a timely response to tackle one area of this problem, the General Assembly has invited all governments to a Conference whose main objective is the elaboration of measures for the concerted action needed to promote the development and utilization of new and renewable sources of energy, in order to meet over-all future energy requirements, in particular, within the context of efforts aimed at accelerating the development of Third World nations.

Not deviating from the central theme of the Conference, I think, there is one fact of enormous political importance which calls for emphasis. For the first time in human history, the impending world energy transition necessitates that the international community work and debate collectively on possible options. This paves the way for the Conference to initiate activities designed to lead toward a new world energy mix based on a pluralistic and diversified framework of available energy sources that can provide a horizon of peace and security. It would be useful to recall here five elements of this energy transition.

The first element is its inevitability. It appears to me that on this topic there is already a commonly agreed point of view. Oil consumption in the world energy mix will continue to play a significant role although of relatively decreasing significance through the end of the century. The demand for oil will be important in the industrialized world where it is expected that the increment in demand will be of the order of 50% and will be 4 to 5 times the present demand of the developing world which requires energy sources to accelerate its process of development and growth. All this will occur regardless of conservation or investment policies. At some moment in the next century, it will be even less significant in the world energy consumption pattern making imperative a new energy mix. This is the inevitable challenge facing the industrialized and developing countries collectively.

The second characteristic is that the transition is viable. It is not possible to say today that the world lacks energy resources. That is not the problem. The problem is the potential scarcity of certain types of fuels, mainly the liquid fuels. Experts have told us on several occasions that energy resources do exist, and point out that the real problem is one of investments in technological resources and in production. We also have learned from the reports prepared for the Conference by the technical panels and expert groups that there will no longer be a single alternative energy source as in the past, but instead a mixture of such sources. Our Conference will deal with 14 energy sources as determined by the General Assembly. A UNITAR Conference has identified more than 40 new sources of energy.

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A third aspect of this energy transition is that it will be much more complex than energy transitions in the past. A complexity due mainly to the fact that humanity has maintained, over many decades, artificially low and depressed fossil fuels prices and that the current adjustment has been produced by a process which has complex implications. Over the short term, the problems of balance of payments, imbalances in the energy bill and imported inflation will affect particularly the developing countries who have not even been able to make adjustments by expanding their exports but who are increasing their indebtedness. At the same time, this transition will mean that, economically, higher and higher proportions of investments will have to be dedicated to energy. In the developing world, this will affect the investment requirements for other economic and social purposes.

The fourth characteristic of the energy transition is that it implies varying degrees of urgency. If we accept the messages we have received from the technical panels and groups of experts involved in the preparations for the Conference, it appears that the world is facing an energy transition which will manifest itself in a different manner for the modern sector of the world economy than for the traditional sector. To the modern sector, the energy transition presents a strong technological challenge to make available a diversity of energy sources. Yet if we follow historical optimism and humanity's achievements over recent decades in the energy field, there would be no room for pessimism: the world, particularly the modern sector, will always find ways to effect an adequate energy transition. On the other hand, a very different situation obtains for the traditional sector basically located in the developing countries. The rural areas of many of these countries are still operating on fuelwood and charcoal and have not yet made the first energy transition. This is an urgent summons, requiring immediate action. The technical panels and the rural energy expert group have dramatically conveyed the pressure that is exerted on natural resources, on the environment and on the forests by this problem. However, because of the special conditions surrounding the traditional sector, it does not necessarily follow that the past scheme of transition from traditional to more modern techniques in more advanced countries could or should be followed by the traditional sector. The complex issues involved demand the attention of the international community if equitable solutions are to be found.

Lastly, I believe that the fifth aspect of the energy transition involves the efficiency in the use of energy as a fundamental element of this transition. This has been noted very clearly by the industrialized countries which in recent years have made very commendable efforts to conserve energy. However, there is still a lot to do to improve the efficiency of primary energy use. When experts tell us that only 15% of the primary energy reaches its end use and that 70 to 80% is lost along the way, this obviously leaves much room for improvement. This is true not only for the industrialized countries but also the developing countries.

The Conference therefore has as its primary objective to examine the options available for an energy transition involving these five characteristics. Another aim of equal importance is to examine the energy transition in the context of the requirements of developing countries. Here is where the need to consider a development strategy provides the energy transition with a new dimension. I do not think that it is necessary to recall once again the direct relation which exists between the use of energy and the degree of development. But recent studies have emphasized that while there is no direct and unambiguous functional relationship between the degree of development and productivity growth, there is a positive relation. Thus, the developing countries will necessarily require much higher supplies of energy to accelerate their process of social and economic development. Analysed in the context of energy development, one can pose the question: Can the developing countries continue to use an energy mix based on the past pattern of energy production and consumption of modern societies, or will it be necessary to face a massive innovative effort to develop a process that provides energy to these countrie that will at the same time take into account the particular conditions and constraints of their economic and social structures? It is both a sovereign right as well as a unique challenge of each country to find an answer to this question within the framework of their development strategies and energy policies. It is a challenge to the responsibilities and solidarity of the international community to find a way to help developing countries obtain the basic energy inputs they need to accelerate their economic and social development.

How then can we promote awareness of the need to prepare and promote this energy transition in developing countries in a way which will be innovative and at the same time ensure the energy required for development? I believe that the first consideration needed is to emphasize that countries cannot consider an energy strategy in isolation. Energy is most definitely a central component of any nation's general development strategy. Within this context, options are more varied and more in consonance with potentialities and constraints of the economies of developing countries. The other important consideration is that when energy strategies in the developing world become part of an overall development policy, they can be used to promote economic and social development. Great imagination is required to formulate strategies for the energy transition that will become not merely simple passive inputs into the development process, but an engine of growth based on the use of natural resources, of labour, and of local technologies. In this context, the Conference can be seen as an element in promoting both the energy transition and economic development.

In order to do that, it is essential to start with a factual and solid inventory of available and potential resources. Then we will need to revise many criteria for evaluating some of the options which will not necessarily correspond to either the micro-economic approach nor the conventional market signs but will have to be based on much more complex macro-economic and social considerations. This leads us to the realization that international co-operation requires a new perspective and new responsibility for the international community. This is the point of confluence for the world energy transition and energy and development problems.

The common global interest to increase the energy available should be based on a diversified and sustainable mix especially those which can ensure humanity with a stream of renewable resources for the future. This effort complements a development strategy that will make an active and dynamic contribution to the economic and social development process during the energy transition.

This Conference, convened by the United Nations, is both technical and political reflecting the wishes of the Member States. It is a Conference on energy dealing with the impending energy transition. But it is also a Conference concerned with development because it deals with the projection of the energy strategy of the over-all development problems of developing countries. Conceived in this way, I submit that the Conference could concentrate its actions on five broad fronts.

The first front is an attempt to improve global awareness concerning the energy transition by initiating a world dialogue on the issues involved. There is an important role to play in the dissemination of accurate knowledge and in the development of ideas leading to improved understanding of this theme in discussions at the national, regional and global levels, in the scientific as well as technical and political fields.

The second point, I believe flows as a direct result of the first. It is the hope that this Conference will lead to an improvement in the inventory of resources at the national level, so that decisions regarding options can be based on this knowledge. Coming from a developing region and having been in direct contact with the governments of Latin America, I can tell you how frustrating it is today for many of these countries in their attempts to decide on energy options, which in most cases require high investments. These decisions are important since they will not only affect the energy future, but also future economic and social development. Thus, it is important that this Conference try to develop policies that lead to an inventory of the technologies which would form the basis for the selection of appropriate options.

The third front points to the need to consider the energy transition at two levels of urgency. In the short term, special priority must be given to the fuelwood and charcoal crisis, a particularly important part of the challenge faced in developing nations. Over the medium term, it will be necessary to accelerate strongly and vigorously technological research which will reduce the time of penetration of the new and renewable energy sources into the energy mix both of developed and developing countries.

A fourth point is the need to stimulate international co-operation, especially through the transfer of financial resources to developing countries, to support energy research, technology transfer and investment and do away with bottlenecks in our attempts to increase and diversify the energy supply, particularly, in developing countries.

Lastly, I would say this Conference should serve to promote a strong co-operative effort within the United Nations system. I believe that, if this Conference can really challenge and stimulate the co-operative and co-ordinative capacities of this system, it will render the UN system more effective in responding to the needs of its Member States.

SUMMARIES: TECHNICAL PANEL REPORTS

One of today's major world energy problems is the rapid increase in the demand and price of oil. In the future both scarcity and cost factors will affect other fossil fuels and uranium, thereby increasing the importance of alternative sources of energy. They are particularly important for the developing countries, many of whose economies are suffering from the adverse balances of payments due to oil imports.

With this setting, the Technical Panel of Experts met, discussed and arrived at reports on the sources of energy chosen for the Conference. Following are brief summaries of these reports.

SOLAR ENERGY

Solar energy is clean, renewable, abundant and widely distributed in a global sense. Nearly all the other sources of energy in the world derive directly or indirectly from solar energy. Although affected by atmospheric conditions and intermittent, solar energy is convertible into mechanical and electrical energy with reasonable efficiency. It is thus a unique source of energy which can and has been used successfully to meet domestic needs for hot water, space heating and cooling, as well as for industrial process heat, and agricultural use such as irrigation, drying and cooling.

The UNCNRSE Technical Panel on solar energy, made up of experts from developing countries such as India, Jamaica, Libya, Mexico, Mali, Madagascar, Nigeria, and Sudan, as well as from several industrialized countries, did not attempt to deal with all of the broader solar technologies but limited itself to passive thermal systems, stationary solar collector systems, solar ponds, tracking collector systems, terrestrial photovoltaic systems, and satellite power systems.

Passive solar collection is the simplest and most cost-effective technology for gathering solar energy, and variations of the technique have been used for centuries. While passive collection systems are basically well understood, there is a considerable need for detailed design performance studies to ensure acceptable ranges of efficiency in operation. Economic incentives are sufficient to merit these studies.

Most stationary solar collectors are of the flat-plate design, which is an easily constructed, low-technology design, efficient and flexible in its application. However, if high construction costs and the need to use imported materials can be overcome, use of flat-plate collectors would gain wide acceptance.

Solar ponds typically two or more metres deep are often stabilized to prevent convection by the artificial creation of a salt gradient. The solar pond combines the advantages of cheap construction with very substantial thermal storage, so energy can be extracted at a fairly constant rate regardless of daily fluctuations in solar energy inputs. Problems associated with this technology are environmental (salt pollution of aquifers) and siting (solar ponds are less efficient at latitudes higher than 40° because the more oblique solar angle leads to increased reflection).

Tracking collector systems are capable of "following the sun" in order to collect as much solar energy as possible and generate very high temperatures. The technical viability of linear focusing concentrators has been established, but the economic prospects of these systems are still not well established.

Photovoltaic generators convert solar radiation into direct electric current. This technology is proven and costs for applications in isolated areas are competitive with traditional sources. Continuing technological advances and favourable socio-cultural and environmental impacts make photovoltaic generators increasingly attractive.

Satellite power systems eliminate the atmospheric and geographical constraints of terrestrial solar collectors. This concept has the potential for broad application in the long term, but a large number of technical, environmental, social and economic problems and/or uncertainties still exist.

The Panel emphasized ten specific applications of solar technology: space heating, domestic water heating, refrigeration and space cooling, solar cooking, water pumping, water purification and distillation, greenhouses, timber and crop drying, power production, and production of heat for industrial processes. The economic viability of solar power for many of these uses is well established. The use of solar energy is particularly promising for agricultural needs and power generation for developing countries.

There are a number of constraints which currently limit the development and use of solar energy technology. Among these are the lack of an adequate solar energy resource data base, institutional and policy constraints, the lack of adequate financing and other economic constraints, the lack of adequate research and development, insufficient transfers of existing technology, and the inadequacy of information, training, and education programmes.

To overcome these constraints the Panel recommended that national agencies be established to facilitate a comprehensive national energy policy which will include solar and other renewable energies. These agencies should also participate in the collection of data, the mapping of solar energy resources, and the introduction of technologies which have been demonstrated to be efficient and economic.

International financial institutions should be encouraged to assist developing countries with the high initial costs of solar energy, and financial incentives should be established to promote production of materials for solar technologies and to facilitate market penetration.

In addition, research and development must be accelerated to render solar energy more cost-effective, and the information resulting from increased research and development should be quickly and freely distributed as one facet of a major public education effort.

Finally, the Panel emphasized that public awareness, exchange of ideas, and appropriate training and education programmes would assist in the adaptation and development of solar energy in those areas of the world to which it is most suited and in which it is most needed.

HYDROPOWER

The mechanical utilization of hydropower appears to have begun about 1500 BC and increased steadily until it reached a peak in the middle ages. With the advent of electricity in the 1880's, the importance of hydropower increased, and by 1925 hydroelectric facilities provided 40% of all electricity produced. At present, 23% of all electricity is produced by hydropower, but only 16.5% of world resources are in use. Some 65% of the world's technically usable hydro resources lie in Africa, South America, and Asia (excluding the USSR), yet today barely 30% of production capacity is in these areas.

The UNCNRSE Technical Panel on hydropower included experts from China, Czechoslovakia, France, Ghana, Guyana, Norway, Sri Lanka, the USSR, the USA, Venezuela, and Fed. Rep. of Germany. Meeting twice in 1980, the Panel worked to identify the state and trends of water power development, constraints faced by developing countries, and measures to overcome these constraints.

The importance of hydropower in the present-day fuel and power system of practically all countries is due primarily to the fact that, of all the renewable sources of energy known today, hydropower is the most practical and effective in terms of utilization on an industrial scale.

Unlike the technologies associated with many new and renewable energy sources, hydropower is well developed. A wide variety of hydropower equipment is now in operation, and its performance has been well demonstrated and proven. The industrial infrastructure for the manufacture of such equipment is well established in many countries.

While the net effect of the vast majority of hydropower projects around the world has been beneficial, there are adverse environmental side effects, some of which, however, could have been eliminated and others reduced in magnitude by careful planning of mitigation measures to keep the adverse changes to a minimum at a reasonable economic cost.

Much experience has been amassed of the constructing and operating of hydroelectric power stations in various regions of the world and under different climatic engineering and/or geological conditions. Although often associated with the world's major rivers, hydropower potential is available elsewhere, for example in tidal inlets. Measured by both the volume of water and the distance the water falls, hydropower potential comparable to that of great rivers can also be found in streams in mountainous areas, or can be created artificially by the construction of large dams with extensive reservoirs, or by the diversion of rivers to sites providing a more abrupt change in altitude.

The economic feasibility of hydropower development is improving compared to other energy sources which use finite fuels. Alternative energy sources considered too expensive in the past are now being actively considered for development because of continually rising cost of fossil fuels, especially oil and gas. With more realistic methodology of economic evaluation including full recognition of the value of non-use of depletable resources and of not being dependent upon fuel resources controlled by others, hydropower becomes increasingly attractive.

The developing countries at present face some constraints which prevent the extensive use of hydropower in these countries where most of the unused hydropower potential is concentrated. The inadequacy of background hydrological, topographic, geological, economic and other data exercise a serious limiting effect. It is not possible to design and implement an optimal water resource development project without substantial knowledge of variation in the flow of the river, and geological data of the site. Adequate cartographic material is also required for many purposes in infrastructural planning, but it is especially important in assessment of hydraulic resources potential and hydropower development. Hydro-resource development should not be conducted without comparison of a hydro project with other suitable electric generation alternatives and without an initial analysis of the economic opportunities associated with multi-purpose utilization of hydraulic resources.

Considerable possibilities for hydropower development are available on international rivers, but their use for power generation is often rendered difficult by the absence of basic legal standards to govern the joint construction and operation of hydropower installations on such rivers.

Lack of skilled personnel, financial constraints and lack of proper institutions on local, national and international levels appropriate to deal with hydraulic energy resource development in these countries also poses a serious limiting effect.

The above-mentioned constraints could, however, be largely eliminated in the near future by the adaptation of the appropriate measures presented in the report.

These measures include recommendations at national and international levels and are aimed at solving hydropower development problems faced by developing countries.

At the national level they include recommendations: to examine hydropower potential in the context of a national natural resource development policy and of potential for rural application of small and micro-hydropower development; to organize proper institutions to deal with hydropower development; to strengthen national research, development and demonstration programmes to help developing countries to assess, select and adapt relevant hydropower technologies; and to work out training programmes to meet trained manpower requirements.

At the international level these recommendations are aimed at: acceleration of standardization of equipment for small-scale hydropower development through joint international collaboration; preparation of worldwide surveys on the manufacturing of hydropower equipment and on the experience of hydropower development in international rivers; intensification through appropriate international organization programmes of technical assistance to these countries; and promotion of collaboration of developing countries in development of large-scale hydropower projects by joint efforts.

Implementation of these recommendations will play a significant role in further development of hydraulic resources in the developing countries.

OCEAN ENERGY

The resources considered by the UNCNRSE Technical Panel on ocean energy included ocean thermal gradients, tides, waves, currents, and salinity gradients. Of these technologies only tidal energy is at present commercially established. Although the utilization of this resource will probably increase over the next twenty years, it will not make a major impact on a global scale or on the energy problems of developing countries. Wave energy is larger in extractable form than tidal energy, but is of most interest in latitudes higher than 30° and is therefore applicable to only a few of the developing countries. Even these few countries, wave energy is unlikely to find wide application in this century because its unit costs are comparatively high. Neither ocean currents nor salinity gradients are considered to have any prospect of commercial application in this century.

The UNCNRSE Technical Panel on Ocean Energy, composed of experts from Chile, France, India, Japan, the United Kingdom, and the USA, judged ocean thermal energy conversion (OTEC) to be the technology most deserving of emphasis based on its projected viability, its significance for developing countries in the next 10-15 years and its amenability to international action.

The most important considerations in assessing the potential application of the OTEC concept relate to physical and environmental factors, sizing, energy end-use, by-products, deployment configurations, and institutional and economic factors.

The selection of the appropriate configuration for a given project will be largely a function of the site's depth and coastal proximity, the desired products, and physical parameters such as weather and sea conditions. The four configurations for commercial-scale OTEC are moored, land-based, shelf-based, and plant-ship facilities. Environmental assessment activities should take place at each potential OTEC site, and environmental acceptability is related to installation size and design configuration. It is necessary to assess potential conflicts with other uses of the ocean environment such as transportation, mining, fisheries, recreation, and waste disposal.

The major factor in determining the degree of utilization of OTEC for power production will be the availability of a thermal resource adequate to support operations. A temperature difference of at least 18 C° between surface waters (0-100 m) and deeper waters (900-1100 m) is essential, coupled with proximity of the 1000-m isobath to the coastline. In addition, other site characteristics including ocean currents and meteorological and sea-bed conditions will affect OTEC viability.

OTEC energy can be converted to either electrical, chemical or protein form. Energy intensive markets can be provided with liquid hydrogen, ammonia, aluminium, methanol, methane, or fertilizer by the utilization of OTEC as an energy intensive process alternative.

Proper sizing of OTEC electrical output is a function of energy demand, available alternative supply, demographics and economic penalties associated with downscaling. The development of smaller-scale plants currently underway is critical to improving OTEC applicability to developing countries.

Economically, small-scale OTEC plants in the 1-10 MW range now appear to be competitive with diesel generators on remote islands and could significantly benefit coastal areas - the traditional focal points of economic growth and human settlement. OTEC may not only provide a source of electricity but also the means to develop new energy-intensive industries in areas which currently have extremely limited prospects for industrial development.

The major impediments to OTEC relate to the lack of demonstrated reliability at full scale, and the need for greater awareness and understanding of the benefits that can be realized by developing countries. Even though OTEC does not require scientific or technical breakthroughs to achieve commercial application, neither utility companies nor international lending institutions will commit their resources to commercial plants before they witness a prototype operating with a reasonable assurance of economic success. The full appreciation of the OTEC opportunity requires training and experience in the design, financing, evaluation, and implementation of OTEC-type projects. Many developing countries lack the qualified personnel to evaluate OTEC's industrial and agricultural applications. Problems relating to the present lack of a participatory role for developing countries in OTEC construction and utilization and impediments arising from insecure investment criteria and under-developed OTEC market research are expected to disappear as a result of technology transfer and reduced industrial insecurity following a successful prototype project.

Having identified the constraints and other issues, the Panel attempted to identify a number of measures that would remove or mitigate the impediments to OTEC development. The Panel strongly recommended that steps be taken on both the national and international levels to assure that a commercially sized OTEC prototype plant be constructed and operated as close as possible to commercial working conditions. In the Panel's view, no other single action would better serve to demonstrate OTEC's reliability and hence encourage the flow of capital to OTEC projects.

With regard to the lack of OTEC development funding, the Panel suggested that a consortium of interested countries, international institutions and private concerns could provide the initiative and expertise necessary to facilitate co-financing of OTEC projects.

To address the paucity of awareness and understanding of OTEC technology and potential, the Panel recommended that, at the national level, developing nations undertake studies to fully assess OTEC's applicability to their individual development needs. OTEC's substitution possibilities relating to rural, irrigation, and industrial applications should be of primary importance. In addition, experience sharing between developing countries with regard to the implementation of new technologies, resource assessment and management, and investment analyses as well as enhanced communication flows between industrial and developing nations were similarly encouraged.

At the international level the Panel suggested that a programme of research be initiated to examine the adaptation of OTEC technology to developing country needs and that a training and education programme be established to provide instruction on OTEC technology and project evaluation and operation. These programmes would serve to describe how OTEC operations differ from conventional power plants operations, and thus foster the credibility of OTEC philosophy.

(Based on summaries prepared by Paul Martin, John Sheehan, James Schlueter, Tanya Chermak and staff of the UNCNRSE Secretariat of the Final Report of the Ad Hoc Technical Panels.)

SCHEDULE OF CONFERENCE MEETINGS

Preparatory Committee (3rd Session)	30 March - 17 April 1981	New York
Preparatory Committee (4th Session)	8 - 26 June 1981	New York
Conference	10 - 21 August 1981 preceded by one week of pre-conference consultations	Nairobi- Kenyatta Conference Centre

NATIONAL FOCAL POINTS FOR UNCNRSE

(PART II)

In order to facilitate the efforts of the UNCNRSE, governments have appointed individuals or institutions to serve as national focal points, to help co-ordinate efforts in their respective countries to participate in and contribute to the UNCNRSE. For our readers' information, we are presenting a list of the approximately 90 countries who have designated official national focal points in two parts, the second of which appears below:

GHANA

Mr. E. Appiah Korang
Secretary to the Committee on Energy Resources
The Office of Petroleum Department
Ministry of Fuel and Power
P.O. Box 1627
Castle Post Office
Osu-Accra

GREECE

Secretariat of the National Council of Energy
Ministry of Co-ordination

GRENADA

Permanent Secretary, Planning
Ministry of Finance, Trade, Industry and Planning
St. George

GUATEMALA

Mr. Jorge Luis Monzon-Juares
Secretario
Secretaria de Minería, Hidrocarburos y Energía Nuclear
Diagonal 17 entre 28 y 30 Calles
Zona 11, Guatemala City

GUYANA

The National Energy Unit
295 Murray Street
Georgetown
Attn: Mr. Bernard Crawford

HUNGARY

Dr. György Vajda
Director
Institute for Electric Energy Research
1051 Budapest
Zrinyi u.l.

cc: Permanent Mission in New York

INDIA

UN Division
Ministry of External Affairs
New Delhi

INDONESIA (REPUBLIC OF)

Department Pertambangan dan Energi
Republik Indonesia
Jalan Medan Merdeka Selatan no. 18
Jakarta-Pusat

IRAN (ISLAMIC REPUBLIC OF)

Merger Planning Management Bureau
Ministry of Oil

IRAQ

Ministry of Oil
National Focal Point on Energy
Baghdad

IRELAND

Directorate for Scientific and Technological Affairs
Department of the Taoiseach
Shelbourne House, Shelbourne Road
Dublin 2

ISRAEL

Division of Research and Development
Ministry of Energy and Infrastructure
P.O. Box 1442
Jerusalem

ITALY

Department of Energy Sources
Ministry of Industry

IVORY COAST

Mr. Lambert Konan
Directeur Général EECI
01 B.P. 13 45 Abidjan 01

JAMAICA

Dr. Henry Lowe
Energy Division
Ministry of Mining and Natural Resources
2 St. Lucia Avenue
Kingston 5

JAPAN

Economic Affairs Division
United Nations Bureau
Ministry of Foreign Affairs

JORDAN (HASHEMITE KINGDOM)

Royal Scientific Society

KENYA

Permanent Secretary
Ministry of Energy
P.O. Box 30582, Nairobi

KUWAIT (STATE OF)

Kuwait Institute for Scientific Research

LIBERIA

Dr. Miedi-Himie Neufville
Director of the Bureau of Hydrocarbon
Ministry of Lands and Mines
P.O. Box 9024, Monrovia

MADAGASCAR (DEMOCRATIC REPUBLIC OF)

Société HERY VAO
c/o Ministère de l'Economie et du Commerce
Antananarivo

MALAWI (REPUBLIC OF)

The Secretary to the President and Cabinet
National Research Council
Private Bag 301
Capital City, Lilongwe 3

MALI

Mr. Cheicknè Traore
Directeur de Laboratoire de l'Energie Solaire du Mali

MALTA

EneMalta Corporation
Central Administration Building
Church Wharf
Marsa

MEXICO

Jefe de Asuntos Económicos
Secretaria de Relaciones Exteriores de Mexico

NETHERLANDS

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Ministry of Foreign Affairs (DIO/HG)
The Hague

NEW ZEALAND

Economic Division
Ministry of Foreign Affairs
Wellington

NIGER

Ministère des Affairs Etrangères et de la Coopération

NIGERIA

Federal Ministry of Science and Technology
Lagos

NORWAY

Mr. Helge Vindenes
Ambassador
The Royal Ministry of Foreign Affairs
7. Juni Plassen 1
Oslo 1

PAKISTAN

Directorate General of Energy Resources
Government of Pakistan

PANAMA

Carlos Algandona
Development Director, IRHE
Edificio Hatillo
Calle 35 y Avenida Cuba

PERU

Oficina Sectorial de Planificación
Ministerio de Energía y Minas

PHILIPPINES

National Science Development Board
P.O. Box 3596
Manila

POLAND (PEOPLE'S REPUBLIC)

Mr. Jerzy Wojcicki, Chairman
Chief Inspectorate of Energy Economy
Krucza 36
00-921 Warszawa

PORTUGAL

Departamento de Energias Renouvaveis
Rua da Beneficencia, 241-4° andar
1600 Lisboa

REPUBLIC OF KOREA

Solar Energy Research Institute
Korea Institute of Science and Technology
Seoul

RWANDA

Mr. Joseph Zigirababili
c/o Ministère des Resources Naturelles
Mines et Carrières

SAINT LUCIA

Ministry of External Affairs

SAUDI ARABIA

Mr. Mohamed Farouk Al-Husseini
Director, Economic Department
Ministry of Petroleum and Mineral Resources

SENEGAL

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Chef de la division des énergies renouvelables
Direction de l'Innovation et du Progrès technologique du Secrétariat d'Etat auprès du Premier Ministre chargé de la Recherche scientifique et technique

SEYCHELLES (REPUBLIC OF)

Principal Secretary
Ministry of Planning and Development
Department of Works
P.O. Box 53, Unity House

SPAIN

Centro de Estudios de Energia
Agustin de Foxa 29
Madrid 16

SRI LANKA

Ministry of Power and Energy
No. 50
Sir Chittampalam A. Gardiner Mawatha
Colombo 2

SUDAN

National Energy Administration
Ministry of Energy and Mining
P.O. Box 2087
Khartoum

SURINAM (REPUBLIC OF)

Head, Division of International Economic Relations
Ministry of General and Foreign Affairs
Paramaribo

SWEDEN

The Swedish National Preparatory Committee for the UN Conference on New and Renewable Sources of Energy
c/o Ministry of Foreign Affairs
Box 16121
103 33 Stockholm

SWITZERLAND

Direction de la coopération au développement et de l'aide humanitaire
Département féderal des affairs étrangères
3003 Berne

SYRIAN ARAB REPUBLIC

Vice Prime Minister for Economic Affairs

THAILAND

Office of the National Energy Administration
Ministry of Science, Technology and Energy
Kasatsuk Bridge
Bangkok 5

TRINIDAD AND TOBAGO

The Chairman
Working Group on the United Nations Conference on New and Renewable Sources of Energy
c/o Ministry of Energy and Energy-based Industries
Salvatori Building
Independence Square
Port-of-Spain

TUNISIA

La Direction des Organisations et Conférences Internationales

TURKEY

The Turkish Science and Technical Research Institute (TUBITAK)

UNION OF SOVIET SOCIALIST REPUBLICS

USSR State Committee for Science and Technology
Gorky Street 11
Moscow K-9, USSR
c/o S. Tsukanov

UNITED KINGDOM

Community and International Policy Division
Department of Energy
Thames House South
Millbank
London SW1P 4 QJ

UNITED REPUBLIC OF TANZANIA

Ministry of Water, Energy and Minerals
P.O. Box 9153
Dar-es-Salaam

UNITED STATES OF AMERICA

Mr. James Stromayer
United States Co-ordinator for the UN Conference on New and Renewable Sources of Energy
International Organizations Bureau (Room 1206)
US Department of State
Washington, DC 20520

URUGUAY

Dirección Nacional de Energía
Ministerio de Industria y Energía
Calle Rincón No. 723
Montevideo

VENEZUELA

Mr. Luis Enrique Berrizbeitia
Dirección de Investigación y Desarrollo
Ministerio de Energía y Minas

YEMEN

Central Planning Organization
Ministry of Development
P.O. Box 175
Aden

ZAMBIA

The Secretary
National Energy Council
P.O. Box RW 50065
Lusaka

For further information concerning the UN Conference and its preparations, please contact:
Information Officer, UN Conference on New and Renewable Sources of Energy
DESI/DPI - Room 1061-J, United Nations, New York, NY 10017, USA   Tel.(212) 754-6875

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The UNCNRSE Conference News section of ASSET is edited by Mary Esther Leung with the support of the ASSET editorial assistant, Yoko Doi.

unit is to demonstrate the feasibility of producing energy for farms (heat and electricity) from methane produced by the anaerobic digestion of crop residues and other crop materials. The acid hydrolysis pre-treatment of corn-stover studies utilize a two-stage sulfuric acid contact. In the first stage, dilute sulfuric acid is used to hydrolyze the pentosan fraction of ground biomass. The second stage uses concentrated sulfuric acid for hexosan hydrolysis. The use of the two steps give high yields, possible with concentrated acid, without the problems of pentose decomposition.

106/81 ALTERNATE ENERGY SOURCES: ORGANIC WASTES AS METHANE SOURCES. W. Ganapini. Acqua Aria, no. 6, p. 407-13 (1978). In Italian.

This review covers the bacteriology and the technology of CH_4 production from organic wastes. 61 refs.

D. WIND ENERGY

107/81 DEVELOPMENT OF VERTICAL AXIS WIND TURBINES. P.N. Shankar (National Aeronautical Laboratory, Bangalore 560 017 (India)). Proceedings of the Indian Academy of Sciences, vol. C2, Pt. 1, p. 49-66 (1979).

This paper summarizes the work done at the National Aeronautical Laboratory between 1975 and 1977 on the development of vertical-axis wind turbines based on the Darrieus rotor. On the analytical side, a performance analysis was developed which permits the estimation of the characteristics of such machines. A 5-m high wind turbine using curved wooden blades was designed, fabricated and tested. Both the theory and initial tests confirmed the low starting torque of the turbine. Wind-tunnel tests were performed on model Savonius rotors to determine optimum starter-bucket configurations. Finally, a straight-bladed turbine was designed and constructed. It is concluded that Darrieus turbines are likely to be useful in large systems used to generate electrical power for the grid. These turbines are unlikely, however, to be suitable for direct water pumping.

108/81 THE ITDG INTERNATIONAL WINDPUMP PROGRAMME: ENGINEERING DESIGN CONSIDERATIONS USED IN DEVELOPING A WINDPUMP SYSTEM FOR SMALL-SCALE MANUFACTURE AND USE IN UNDER-DEVELOPED ARID OR SEMI-ARID REGIONS. P.L. Fraenkel (Intermediate Technology Development Group Limited, 9, King Street, London WC2E 8HN (UK)). Proceedings of the Indian Academy of Sciences, vol. C2, Pt. 1, p. 83-105 (1979).

In this paper, some of the reasons why windpumps have not readily found wide-spread application in the developing arid regions, despite the fact that they have been widely and successfully applied in the USA and Australia, are discussed, in the context of the London-based Intermediate Technology Development Group's (ITDG) investigative work and field experience with windpumps. Following from this is a description of ITDG's International Windpumps Development Programme, which is intended to overcome some of the previous shortcomings of windpumps when applied to industrially developing regions. Lastly, there is an account, in some detail, of the engineering approach chosen in designing the ITDG windpump prototype for development under the international programme.

109/81 COMPARATIVE PERFORMANCE MEASUREMENTS ON A SAVONIUS ROTOR WITH ANCILLARY SURFACES. D.V. Nguyen (Ecole Polytechnique de Thiès, Thiès (Senegal)). Wind Engineering, vol. 3, no. 2, p. 115-20 (1979).

In an attempt to improve the performance of the conventional Savonius rotor, a model rotor was fitted with ancillary surfaces of aerofoil and umbrella form to produce six alternative configurations. Wind-tunnel tests on the models showed the performance to be improved in only one case; in the other units tested, the drag effect of the ancillary surfaces appeared to predominate over any possible flow improvement.

E. ENERGY STORAGE

110/81 LOW-TEMPERATURE THERMAL ENERGY STORAGE: A STATE OF THE ART SURVEY. Solar Energy Research Institute, Golden, CO, USA. SERI/RR-54-164 (July 1979) 119p. NTIS. US$11.50.

The preliminary version of an analysis of activities in research, development, and demonstration of low-temperature thermal-energy storage (TES) technologies having applications in renewable energy systems is presented. Three major categories of thermal-storage devices are considered: sensible heat, phase-change materials (PCM), and reversible thermochemical reactions. Both short-term and annual-thermal energy-storage technologies based on principles of sensible heat are discussed. Storage media considered are water, earth, and rocks. Annual storage technologies include solar ponds, aquifers, and large tanks or beds of water, earth, or rocks. PCM storage devices considered employ salt hydrates and organic compounds. The sole application of reversible chemical reactions outlined is for the chemical heat pump. All programme processes from basic research through commercialization efforts are investigated. Non government-funded industrial programmes and foreign efforts are outlined as well. Data describing low-temperature TES activities are presented also as project descriptions. Projects for all these programmes are grouped into seven categories: short-term sensible heat storage; annual sensible-heat storage; PCM storage; heat transfer and exchange; industrial waste heat recovery and storage; reversible chemical-reaction storage; and models, economic analyses, and support studies. Summary information about yearly funding and brief descriptions of project goals and accomplishments are included.

111/81 STORAGE OF LOW TEMPERATURE HEAT: SOLAR ENERGY THERMAL STORAGE. G. Wettermark and J. Kowalewska (Tekniska Hoegskolan, Stockholm (Sweden)). (Sept. 1976) 48p.

The major means available for thermal storage of solar energy are reviewed and the general conditions for heat storage are discussed. The various types of sensible and latent-heat storage are covered.

112/81 ORGANIC MOLECULAR ENERGY STORAGE REACTIONS. W.H.F. Sasse (Commonwealth Scientific and Industrial Research Organization, Melbourne (Australia)). P. 227-48 of Proceedings of the International Conference on Photo Conversion and Storage of Solar Energy (held London, Ontario, Canada, 24 Aug. 1976). Academic Press, New York, NY, USA.

.In this paper an attempt Is made to identify several key factors that govern the performance of energy-storing organic photoreactions delivering heat. Several examples of such reactions are described and compared. The specific storage capacities recorded so far compare favourably with storage media such as water ($4.2\ J\ ^{\circ}K^{-1}\ G^{-1}$), rock ($0.88\ J\ ^{\circ}K^{-1}\ G^{-1}$), and some eutectics (referred). The temperature ranges of heat evolution observed were mainly between 100 and 200 °C and although aromatic dimers function without detectable damage at high temperatures, thermal damage is clearly a problem with compounds containing olefinic double bonds. Major improvements in the rates of storage are possible in all systems described by paying attention to photophysical and photochemical details.

F. SOCIO-ECONOMIC ASPECTS

113/81 FOOD, ENERGY AND SOCIETY. D. Pimentel and M. Pimentel (Cornell University, Ithaca, New York 14853 (USA)). Edward Arnold, London, UK (1979). 286p.

This book examines the use of energy over many centuries and from many sources to grow food. Regardless of the types of energy used, energy has been expanded to meet the basic need for food. Ample fuel-energy supplies had made it possible to keep up with the ever-increasing human birth rate. However, at present the birth rate remains high while energy reserves, especially from fossil fuel supplies, are diminished. Thus, by the year 2000 when the world population to be fed will have nearly doubled, the strategy needed to meet such a tremendously increasing demand will have to be developed. However, before such plans can be made, much information is required about the energy costs of the diverse food-production systems now employed. These costs must be balanced against the supply of energy that will be available. This book explores the interdependence of food and energy and their impacts on society in the hope that information obtained can be used as a basis for the planning and employment of policies required to feed everyone equitably in spite of the limited resources available. 208 refs.

114/81 FOOD OR FUEL: NEW COMPETITION FOR WORLD'S CROPLAND. L.R. Brown (Worldwatch Institute, 1776 Massachusetts Avenue, N.W., Washington, DC 20036 (USA)). Interciencia, vol. 5, p. 365-72 (1980).

The rising price and uncertain future of world oil supplies have triggered an intense international search for alternative liquid fuels. Many countries are turning to alcohol distilled from farm commodities as a source of fuel for automobiles. Ethanol can be produced from the fermentation of sugar crops, principally sugarcane, root crops including cassava and all major cereals, especially corn and wheat. Familiarity with the technology of ethanol production has helped make it the most attractive short-run alternative for gasoline in the 1980s. The demand by motorists for fuel from energy crops represents a major new variable in the food and population equation. As countries turn to ethanol distilled from agricultural commodities, more and more farmers will have a choice of producing food for people or fuel for automobiles. They are likely to produce whichever is more profitable. Thus, the stage is set for direct competition between the affluent minority, who owns the world's automobiles, and poorest segments of humanity, for whom getting enough food to stay alive is already a struggle. This article examines the present situation for Brazil and the USA in particular. It is concluded that a carefully designed alcohol fuel programme could support food production rather than undermine it. Giving farmers' first priority in the use of ethanol for tractors, farm trucks and irrigation pumps would help insure food supplies when oil supplies begin to dwindle. An alcohol fuel industry that used agricultural wastes, food industry by-products and cellulosic materials such as cornstalks would become an important and renewable source of fuel. The issue is whether governments can encourage the production of alcohol fuel without inadvertently launching an industry that competes directly with food production.

La elevación de los costos y el incierto futuro del abastecimiento de petróleo en el mundo han provocado una intensa búsqueda internacional por combustibles líquidos alternos. Muchos países se están dirigiendo hacia el alcohol destilado a partir de diversas frutas o legumbres como fuente de combustible para sus automóviles. El etanol puede ser producido a partir de la fermentación del azúcar, en especial del que proviene de la caña, o de raíces, principalmente la yuca, así como de los principales cereales, especialmente el maíz y el trigo. El extenso conocimiento que se tiene sobre la producción de etanol ha ayudado a que ésta se convirtiera en la mejor alternativa a corto plazo para la gasolina de los años ochenta. La demanda de combustible a partir de cultivos como fuente de energía para los motoristas representa una grande y nueva variable en la ecuación alimento/ población. A medida que los países se vuelquen hacia el etanol como fuente de combustible para sus automóviles, cada vez más los agricultores tendrán que elegir entre producir alimento o combustible. Es probable que escojan la alternativa más lucrativa. En ese trasfondo, habrá competencia directa entre las minorías opulentas, que son propietarias de los automóviles, y los sectores pobres de la humanidad, para quienes ya constituye una lucha conseguir suficiente alimento para no morirse. Este artículo examina la situación actual, en particular la del Brasil y los Estados Unidos de América. Un programa de alcohol cuidadosamente diseñado podría apoyar la producción de alimentos en vez de debilitarla. El suministro futuro de alimentos cuando vaya disminuyendo el suministro de petróleo será facilitado dando a los agricultores primera prioridad en el uso de alcohol para tractores, camiones de finca y bombas de irrigación. Una fuente importante y renovable de combustible podría provenir de una industria de alcohol que usara desechos agrícolas, subproductos industriales y materiales celulósicos. Específicamente, el problema consiste en si los gobiernos pueden alentar la producción de alcohol para combustible sin establecer involuntariamente una industria que compita directamente con la producción de alimentos.

115/81 THE COMMUNITY FACTOR IN COMMUNITY BIOGAS PLANT. M.K. Bannerjee and L. Jayprakash. Urja, vol. VI, nos. 1-2, p. 53-5 (28 July 1979).

This article proposes that biogas plants in India be developed at the community level and provides some pointers for conducting relevant research on the software aspects of such plants. The article concludes with some observations on current Indian government proposals for extending the use of biogas plants. It is pointed out that research on the software aspects of installing community biogas plant is essential. 3 refs.

116/81 SOCIAL AND ECONOMIC ASPECTS OF THE INTRODUCTION OF GASIFICATION TECHNOLOGY IN THE RURAL AREAS IN DEVELOPING COUNTRIES, e.g. TANZANIA. M.J. Groeneveld and K.R. Westerterp (Department of Chemical Engineering, Twente University of Technology, Enschede (Netherlands)). P. 27-40 of Chemical Technology for Developing Countries (Proceedings of the International Conference of the Nigerian Society of Chemical Engineers, held Zaria, Nigeria, 4-6 November 1979). Nigerian Society of Chemical Engineering, Zaria, Nigeria (1979).

This article describes a gasification process used to generate power for rural areas requring a relatively small quantity of energy. To identify the social and economic advantages of this process, a study was carried out to examine its applicability to the rural areas of Tanzania. This included an evaluation of the selection of a suitable food stuff, the macro- and micro-economic aspects, and a comparison of this process with the existing socio-cultural system. 9 refs.

SELECTED ARTICLE

STORAGE OF SOLAR ENERGY

by

S. Kakaç and Y. Yener
Mechanical Engineering Department, The Middle East Technical University
Ismet Iñoü, Bulvari, Ankara, Turkey

Paper presented at the First International Symposium on Non-Conventional Energy held at the International Centre for Theoretical Physics, Trieste, Italy, 27 August - 21 September 1979. Revised and published by permission.

1. INTRODUCTION

Until 1973, the very low cost and seemingly inexhaustible supply of fossil fuels, such as natural gas and oil, nurtured an industrial and commercial philosophy, particularly in the industrialized countries, where conservation of energy played only a minor role. However, the 1973 oil crisis and the concomitant recognition of the finite nature of earth's oil and gas reserves led inevitably to an urgent call for energy conservation and the development of alternative energy sources.

Energy storage of all types plays an important role in energy conservation. In processes which are wasteful of energy, storage results in a saving of premium fuels. In addition, the imbalance which occurs between the availability of energy and the requirements for its use, which exists in virtually any system, can be evened out by energy storage with consequent savings in capital costs.

Although the sun provides an abundant, clean, and safe source of energy, its supply is periodic following yearly and diurnal cycles, and is also intermittent, often unpredictable and diffuse. Its density is low compared with the energy-flux density found in conventional fossil-energy devices like coal- or oil-fired furnaces. The demand for energy, on the other hand, is also unsteady following yearly and diurnal cycles for both industrial and personal needs. Therefore, the need for the storage of solar energy cannot be avoided. Otherwise, solar energy has to be used as soon as it is received. The annual insolation to the earth's surface amounts to 17×10^{17} kWh. In comparison, the present energy obtained from fossil fuels and water power amounts to about 70×10^{12} kWh. However, the use of solar energy is presently limited because of inefficient collection and storage technology.

Solar energy cannot be stored as electromagnetic energy, but must first be converted into another form. It can, for example, be stored as thermal energy by the heating, melting or vaporization of a material - the energy becoming available as heat when the process is reversed.

As an alternative mode of storage, the energy can first be utilized to produce a fuel, such as hydrogen, and can later be used upon demand to replace gasoline in automobiles, airplanes, and other vehicles. Solar energy can also be used to pump water to a higher level where it is stored behind a dam to be used as hydroelectric energy as required. It can alternatively be stored immediately after it is converted into electricity.

The possible types of thermal storage of solar energy are shown in Fig. 1.

One of the important characteristics of a storage system is the length of time during which energy can be kept stored with acceptable losses. If solar energy is converted into a fuel, such as hydrogen, there is no such time limit. However, storage in the form of thermal energy is possible for only very short times because of losses by radiation, convection and conduction. Another important characteristic of a storage system is its energy density (energy/volume). Systems that have a large energy density are always considered superior.

2. THERMAL STORAGE OF SOLAR ENERGY

Problems associated with solar thermal-energy storage systems based on materials in which heat is stored either as sensible heat or as latent heat of fusion are reviewed in this section. The major problem with this process is the selection of materials having suitable thermo-physical characteristics.

Thermal-energy storage obtained by increasing the temperature of an appropriate material is called sensible-heat storage. Its effectiveness depends on the specific heat and, if the volume is important, on the density of the material.

Storage obtained by phase-change (the transition from solid to liquid or from liquid to vapour without any change in temperature) is known as latent-heat storage. The latent heat of fusion, or heat of vaporization, and the temperature at which the phase change occurs, are obviously of major importance. Both sensible and latent-heat storage can occur in the same material, as when a solid, for example, is heated to its melting point, melted, and then heated again to a higher temperature.

Selection of a particular solar thermal-energy storage mode, basic technology for a given application, and the resultant system performance and economics, depend on detailed engineering efforts. In some cases, the technology is in an arrested state of development, in others it is developing rapidly; however, basic design and operating experience is generally inadequate. Thus, development of a broad spectrum of thermal-storage technology appears to be warranted.

Thermal storage of solar energy is important for low-temperature solar applications. Low-temperature thermal-energy storage may be defined to mean the storage of heat that enters and leaves the reservoir at temperatures below 120 °C. Storage of this type may permit efficient utilization of thermal energy that otherwise would have been partially or entirely wasted. In principle, low-temperature storage permits the storage of thermal energy that is obtained from solar radiation from day to night and/or from summer to winter. It also permits the storage of cold for air-conditioning purposes. On a diurnal basis, the storage efficiency can be well above 90%, while on a seasonal basis it is usually not much above 70%. Furthermore, low-temperature thermal-energy storage presents no significant material problems.

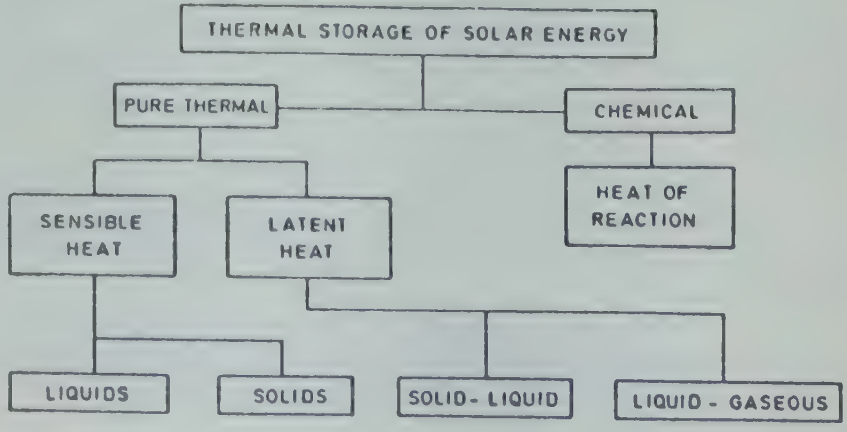


Fig. 1. Types of thermal storage of solar energy

Basically, there are two feasible systems to store thermal energy for low-temperature applications:

1 - Sensible-heat storage systems

  a) Water-storage systems
  b) Packed-bed storage systems

2 - Latent-heat (phase-change) storage systems

2.1 Sensible-Heat Storage Systems

Solar thermal-energy storage systems based on materials which store energy as sensible heat are called sensible-heat storage systems. Those most generally used for low-temperature applications employ water or rock-piles as the storage medium.

The effectiveness of sensible-heat storage systems depends on the specific heat and, if volume is important, on the density of the storage medium. Table 1 gives specific-heat values of typical storage media. The total heat capacity, Q_s, of a storage unit is defined as

$$Q_s = (mc_p)_s(T_1 - T_2) \qquad (1)$$

where T_1 and T_2 are the operating temperature limits, m is the mass, and C_p is the specific heat of the storage material. Equation (1) shows that 4190 kJ can be stored if 1 m^3 of water is heated 1 C°. Only half of that can be stored in a rock pile with the same volume.

The following summarizes some of the general operational problems of sensible-heat storage systems:

- As the temperature of the storage medium rises during collection, greater and greater heat losses are experienced;
- As the temperature drops during heat deposition smaller and smaller heat flux deliveries are possible; and
- Since heat storage occurs at temperatures higher than the ambient, the system must be insulated to prevent heat losses. This adds to the system's cost.

2.1.1. Water-Storage Systems

Water, being inexpensive and widely available, can be effectively used to store sensible heat. The advantages and disadvantages of such storage can be summarized as follows:

Advantages:

- Water is inexpensive, easy to handle, and widely available;
- Water has one of the largest specific heat values;
- Heat exchangers can be avoided if water is used as the heat carrier in a collector;
- Natural convection can be utilized when energy for pumping is scarce;
- Simultaneous charging and discharging of the storage tank is possible; and
- Adjustment and control of such a water system is variable and flexible.

Disadvantages:

- Water can freeze or boil;
- Water is highly corrosive; and
- Working temperatures are limited by the boiling point of water (100 °C) and often have to be far below this value.

Freezing and corrosion problems can be met by chemical additives.

Figure 2 gives the essentials of water-storage systems. Assuming that the storage tank has a uniform temperature distribution, the energy balance in the storage tank is given by

$$(mc_p)_s \frac{dT_s}{dt} = Q_c - Q_L - (UA)_s(T_s - T_a) \qquad (2)$$

where c_p is the specific heat, m is the mass of the water in the tank, Q_c is the rate of heat addition from the collector, Q_L is the rate of heat removal by the load, U is the over-all heat-transfer coefficient between the water in the tank and the ambient temperature, T_a, and A is the surface area of the storage tank.

If for a reasonable time period, Δt, the amount of heat added and removed is assumed to be constant, Eq. (2) can be written for each time interval as

$$T_{s,new} = T_{s,old} + \frac{\Delta t}{(mc_p)_s}\,[Q_c - Q_L - (UA)_s(T_{s,old} - T_a)] \qquad (3)$$

Taking, for example, one-hour intervals, the temperature of the storage medium after several hours can be estimated if the hourly heat addition and removal values are known [2].

Table 1: Properties of specific heat media [1, 2]

Material	Density kg/m^3	Specific Heat kJ/kg·K
Water	1000	4.19
Rock	2500-3500	0.88
Iron	7860	0.50
Concrete	2250	0.65
Water-Ethylene Glycol 50/50	1050	3.47

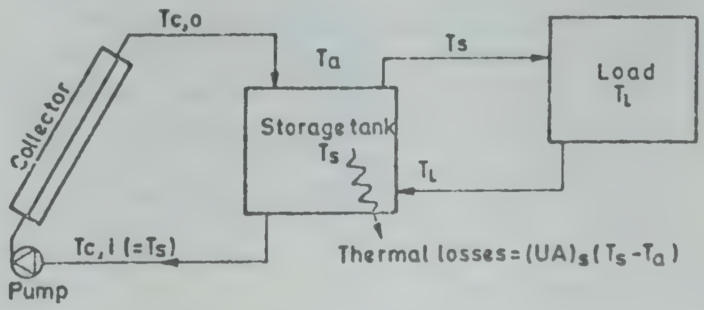


Fig. 2. Essentials of water storage systems

The rate of heat addition, Q_c, by the collector can be written as

$$Q_c = (\dot{m}c_p)_c(T_{c,o} - T_s) \tag{4}$$

where $\dot{m}$ is the flow rate of water in the collector and c_p is its specific heat. In writing Eq. (4), it is assumed that there is no temperature drop of the fluid between the collector and the tank.

Similarly, the rate of heat removal by the load, Q_L, can be written as

$$Q_L = (\dot{m}c_p)_L(T_s - T_L) \tag{5}$$

where $\dot{m}$ is the flow rate of the load stream and it is again assumed that there is no temperature drop between the tank and the load.

In the above analysis, the temperature of the storage medium has been assumed to be uniform. In real situations, however, the water temperature in the tank is not uniform, especially in the vertical dimension. The incoming water seeks its own density level, provided that it enters the tank with a low velocity; that is, the warmer (lighter) water is stored on top of the colder (heavier) water, resulting in thermal stratification. Analysis can be performed if uniform temperature stages over the vertical dimension of the storage tank are assumed.

Thermal stratification improves both storage and collector performance; that is, water at a temperature higher than the overall mixing temperature can be extracted from the top of the container and water at a temperature lower than the mixing temperature can be drawn off from the bottom. Thus, the system can make use of even short insolation periods and work at a higher efficiency. The maintenance of thermal stratification in the water tank requires extremely good insulation or special installations, otherwise natural convection currents will destroy the temperature layers.

One possible way to assist stratification is, for example, by using a thin plastic tube of the same density as the water as illustrated in Fig. 3. The tube moves up and down according to the density of the hot water, placing the warm water in the right side of the tank [3].

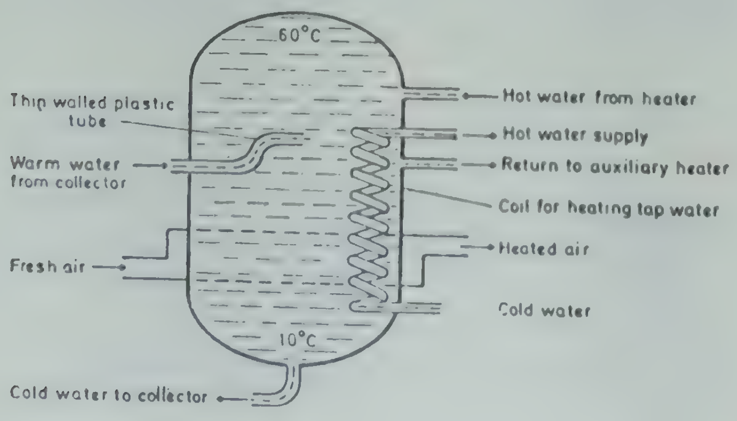


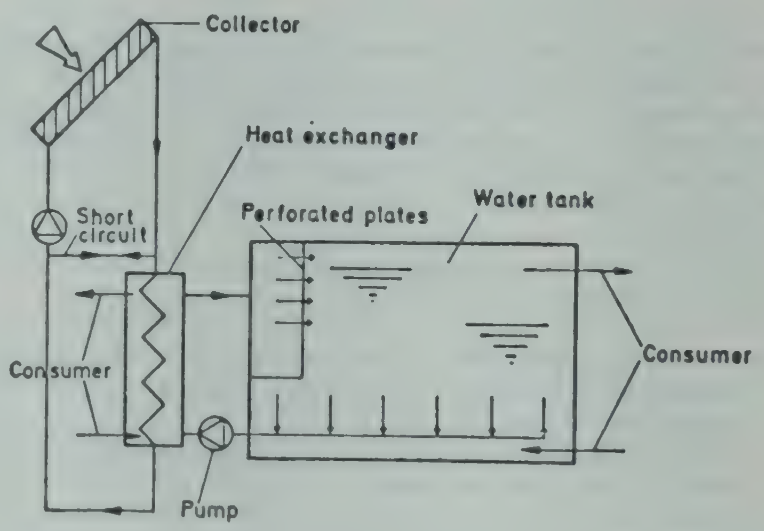
Fig. 3. A simple idea assisting stratification [3]

External and internal heat exchangers can also be used to assist in the stratification process as illustrated in Fig. 4. A heat exchanger is constructed so as to optimize heat transfer throughout its structure and is placed and utilized in such a way as not to disturb the temperature distribution within the tank. Charging and discharging processes and positions of the heat exchangers can greatly affect the stability of the thermal stratification.

When the fluid in the collector and in the distributing circuit are not the same as in the storage medium, fully mixed tanks are used with heat exchangers as illustrated in Fig. 5.

The design of combination solar-collection and storage systems requires careful integration and optimization procedures to minimize unfavourable economics. Simulation and optimization information of solar energy collection and storage for home heating is given in Ref. [4].

(a) External Heat Exchanger



(b) Internal Heat Exchanger

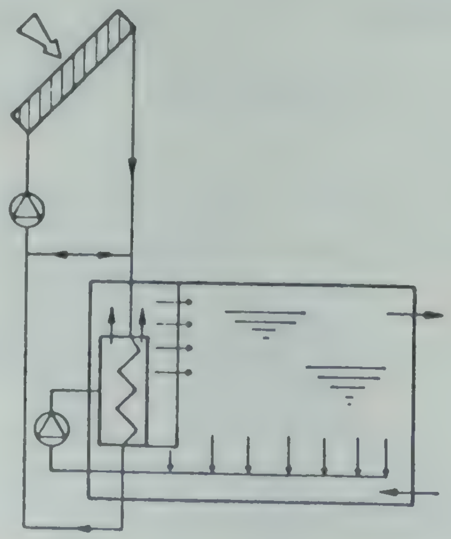


Fig. 4. Arrangements of heat exchangers

2.1.2. Packed-Bed Storage Systems

In these systems, pebble beds or rock piles are usually preferred as the storage material through which air is circulated as the energy carrier since the cost of the storage material is low; the heat-transfer coefficient between the air and the solid is high; and the conductivity of the bed is very low when air flow is not present, thus minimizing heat losses from the storage unit. In Fig. 6 a typical packed-bed storage unit is shown. Flow distribution vanes are included in this system to help insure a unfirom flow over the cross-section of the storage tank.

The advantages and disadvantages of such storage systems may be summarized as follows:

Advantages:

- The material is widely available, easy to handle and cheap;
- High storage temperatures are possible;
- Heat exchangers can be avoided; and
- There are no freezing, overheating or corrosion problems if air is used as the heat carrier.

Disadvantages:

- Storage volumes are large;
- Simultaneous charging and discharging are not possible unless special arrangements are made; and
- The cost of producing air circulation is high.

A well designed bed should have particles of uniform size that are small enough to minimize temperature gradients. In practice, pebbles and rocks of sizes from 2 to 5 cm in diameter are used [2].

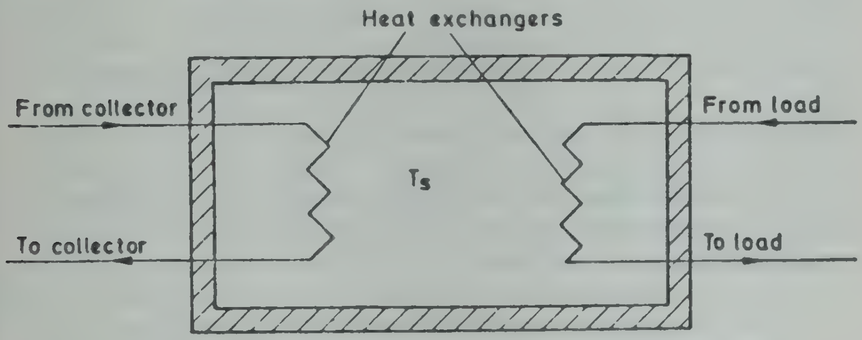


Fig. 5. Fully-mixed storage with heat exchangers

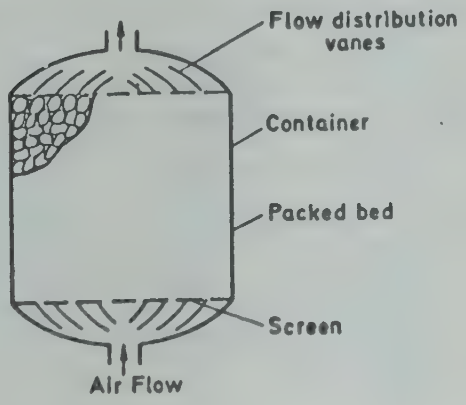


Fig. 6. Packed-bed storage unit

"The storage capacity", which indicates how much heat can be stored per unit time, and the "thermal diffusivity", which indicates how fast heat diffuses within the storage medium, should be as high as possible for storage purposes. The storage capability and thermal diffusivity of various materials are given in Table 2. Granite is superior to concrete brick, soil, sandstone and limestone.

Pebble-storage units can form an integral part of various architectural structures. They can, for instance, be used as columns or as part of the foundation.

2.2 Latent-Heat (Phase-Change) Storage Systems

Materials that undergo a phase change in a suitable temperature range can be used for solar thermal-energy storage. The principle involved is that when collected heat is applied to an appropriate material it changes phase (usually from solid to liquid), thus storing the solar energy as latent heat of fusion. When the collectors are not operating, the material can again change phase from liquid to solid, releasing the heat of fusion.

Heat storage through phase change has the advantage of compactness since the latent heats of fusion of most materials are very much larger than their specific heats. For example, the ratio of latent heat to specific heat of water is 80, which means that 80 times as much energy is required to melt one kilogram of ice than to raise the temperature of one kilogram of water one Celsius degree.

The materials that are to be used for phase-change storage must satisfy the following conditions:

- The material should have a melting point within a suitable temperature range. This range must be 55 ± 10 °C for solar heating applications and 10 ± 5 °C for solar cooling applications.
- The material should have a large latent heat of fusion. Water has one of the largest heats of fusion, but its freezing temperature is too low for most solar energy applications.
- The material should melt congruently, that is, it should melt completely at a fixed temperature or within a very narrow range of temperatures. Otherwise, changes in the chemical composition of the

Table 2: Storage capability and thermal diffusivity of various materials [5]

Material	Storage Capability* $b = \sqrt{k\rho c}$, Ws $^{1/2}$/m^{2}K	Thermal Diffusivity* $\alpha = k/\rho c$, m^2/s
	10^{-3} b	10^{6} α
Copper (commercial)	36	107
Gravel concrete	1.6	0.661
Brick (dry)	~0.8	~0.32
Soil (rough gravel)	1.49	0.157
Sandstone	~1.7	~1.15
Limestone	~2.0	~1.2
Granite	2.7	1.18
Styrofoam	0.023-0.075	0.36-1.54

*k, ρ and c are the thermal conductivity, density and specific heat of the materials.

material may occur because of the difference in densities between the solid and liquid phases, causing the heat storage capacity to decrease.
- The material should not become supercooled (cooled below its freezing point without first freezing). Supercooling changes the energy-temperature behaviour of the storage material. To overcome this, nucleating agents are used.
- The material should be stable, being reversible over a large number of cycles without serious deformation.
- The material should be inert and not interact with its container.
- The cost of the material and its containers must be reasonable.

There are a number of materials which seem appropriate for various temperature levels. For solar energy storage applications, especially with flat-plate collectors, the temperature range of 30 to 100 °C is feasible. Paraffin-water and salt-hydrates can be considered for this range. Table 3 gives some of the materials used for phase-change storage and their properties. Only those materials are listed that are non-toxic, low in cost, and readily available in large quantities. Low-cost materials are usually limited to sodium, calcium and magnesium compounds in the form of their chlorides, carbonates, nitrates, sulfates, or phosphates.

For heating systems, the extensive studies performed by Telkes [6] give a clear outline of possibilities of virtually all available salt hydrates beginning with the familiar Glauber's salt, $Na_2SO_4 \cdot 10\ H_2O$. It was found that this salt degrades upon repeated cycling.

Table 3: Heat transfer properties phase-change storage materials [6]

Material	Chemical Compound	Melting Point °C	Heat of Fusion kJ/kg	Density kg/m^3
Calcium chloride hexahydrate	$CaCl_2 \cdot 6H_2O$	29-39	177	1,634
Sodium carbonate decahydrate	$Na_2CO_3 \cdot 10H_2O$	32-36	247	1,442
Disodium phosphate dodecahydrate	$Na_2HPO_4 \cdot 12H_2O$	36	265	1,522
Sodium sulfate decahydrate	$Na_2SO_4 \cdot 10H_2O$	31-32	251	1,534
Sodium thiosulfate pentahydrate	$Na_2S_2O_3 \cdot 5H_2O$	48-49	209	1,666

Table 4: Properties for storage of one million kJ heat using water or sodium sulfate decahydrate [7]

Material	Density kg/m^3	Specific Heat kJ/kg·K	Heat of Reaction of $Na_2SO_4 \cdot 10H_2O$ kJ/kg	Heat Storage of 10^6 kJ with 10 °C Temperature Difference	
				mass kg	volume m^3
Water	1,000	4.19	-	23,870	23.87
$Na_2SO_4 \cdot 10H_2O$	1,457.8	1.96	251	3,695	2.53
$Na_2SO_4 \cdot 10H_2O$ and water	1,273.6	-	244	4,098*	3.22*

* Does not include the contribution from the specific heat.

As its temperature increases beyond its melting point, it separates into a solution and a solid; and since the density of the solid is higher than that of the solution, a phase separation occurs. This problem is overcome by adding gels or other agents.

The storage of heat in salt hydrates is in the form of heat of fusion, which is the latent heat of reaction. If the latent heat of reaction is large, much heat can be stored in a relatively small volume as illustrated in Table 4. At certain temperatures, these materials release their water of crystallization and the solid remainder dissolves in it totally or in part. Problems are encountered with sub-cooling of the melt, that is, the temperature of solidification shifts to a non-constant value which is lower than the temperature of liquefaction.

A problem for which a satisfactory solution has not yet been found is the charging and discharging of the latent-heat storage system. In most cases, the storage material is encapsuled. The thermal diffusivity of these capsules should not be much lower than that of the storage material, and plastics are suitable in most cases. The capsules have to be arranged in such a way that heat transfer to and from their surfaces is high but does not result in large pressure drops. In order to establish quick propagation of a temperature front, thin-sheet arrangements or, even better, small spheres can be used.

For a solar energy heating system, the peculiarities of the phase-change material have to be considered. The heat carrier coming from the solar collector has to have at least the transition temperature before the anticipated storage mechanism can work. In Fig. 7, two arrangements of a latent-heat storage system are illustrated. With an additional small water reservoir, use could be made even of short-term insolation. Instead of two containers there can be a combination of both in a so-called "hybrid storage", where sensible heat is stored in the water and latent heat in an encapsuled melting material which floats in the water.

The operational problems of latent-heat storage systems, depending on the heat-storage material, can be summarized as follows:

- Because of the nature of phase-change materials, the material itself is not usually used as a heat-transfer agent;

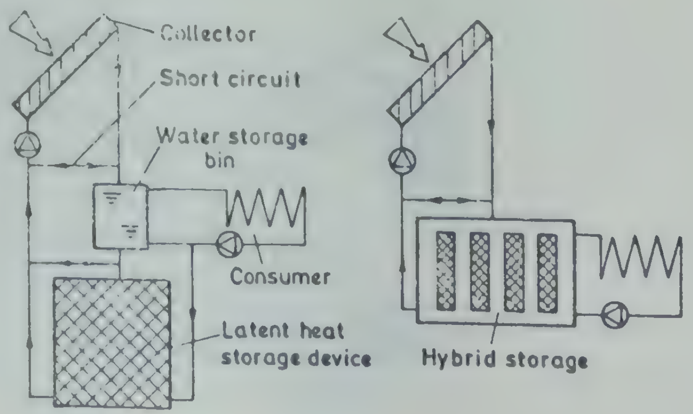


Fig. 7. Two arrangements of a latent-heat storage system

- Phase-change materials have, in general, low thermal diffusivities, thus necessitating special and expensive heat exchangers;
- Corrosion of the containers can introduce impurities that affect performance;
- Careful consideration must be given to the design of heat exchangers to ensure that the phase-change material freezing rate can keep up with the rate of heat removal;
- Phase-change materials are usually expensive; and
- If storage temperatures are significantly different from the ambient specially insulated storage containers are required.

An arrangement which comprises both the solar collector and the storage bin is the so-called "solar pond" suggested by Tabor [8]. This is a big water-filled pond. A fraction of the incident radiation penetrates the water and is absorbed by a blackened bottom. In order to prevent natural convection currents from being established at this heated bottom, suitable salts are dissolved in the lower layers of the water in order to increase their density. Thin film of plastic, horizontally inserted in the pond, can be used to suppress diffusion processes. To compensate for evaporation losses from the surface, fresh water has to be available. The efficiency of a particular solar pond in Israel is reported to be 25%.

Latent-heat storage materials for temperature ranges beyond 100 °C are available. A list of such materials is given in Table 5 with their transition temperatures and heats of fusion [5].

In general, the storage of energy as latent heat still has a number of problems which have not been solved satisfactorily enough to make this concept economically feasible.

3. STORAGE IN THE FORM OF FUEL

There are many forms in which solar energy can be stored through chemical reactions. Chemical storage involves an endothermic reversible reaction which can be reversed when the release of heat is required. The chemical produced can often be stored at a cold temperature (without losses) and can, also, often be transported easily.

Table 5: Latent heat storage materials and their temperature ranges

Temp-range °C	Material	Transition Temperature °C	Heat of Fusion kJ/kg
0-100	Water	0	335
	Paraffin	20-60	140-280
	Salthydrate	30-50	170-270
100-400	$AlCl_3$	192	280
	$LiNO_3$	250	370
	Na_2O_2	360	314
400-800	50%LiOH-50%LiF	427	512
	$KClO_4$	527	1,253
	LiH	699	2,678
800-1,500	LiF	868	932
	NaF	993	750
	MgF_2	1,271	936
	Si	1,415	1,654

For a reaction to be seriously considered for solar energy storage, the following conditions should be met [9]:

- The reaction should be reversible;
- The reactant, with or without the addition of a photo-sensitizer, should be able to use as much of the solar spectrum in the terrestrial atmosphere as possible;
- The energy stored in the reaction should be fairly large (at least of the order of 60 Wh/kg); and
- The reactants should be cheap.

If the products of a reaction can be separated and stored as a fuel, then the reaction does not have to be reversible.

An example is the production of hydrogen. There are, in fact, four main hydrogen-producing methods in which solar energy can be used: direct thermal, thermo-chemical, electrolytic, and photolytic.

If water (steam) is heated to about 3000 °K or above, it will start to decompose into hydrogen and oxygen. This reaction can be expressed as

$$H_2O + (\text{heat}) \rightarrow \eta_1 H_2O + \eta_2 H_2 + \eta_3 O_2 \qquad (6)$$

The substances are in a gaseous form and η_1, η_2 and η_3 are the molar fractions [10].

In thermo-chemical processes, two or more chemical-reaction steps are needed for a complete thermo-chemical hydrogen-producing cycle. The following is an example of such a four-step cycle which occurs at 730 °C with a 50% efficiency [9]:

$$2H_2O + CaBr_2 \rightarrow Ca(OH)_2 + 2HBr \qquad (7)$$

$$2HBr + Hg \rightarrow HgBr_2 + H_2 \qquad (8)$$

$$HgBr_2 + Ca(OH)_2 \rightarrow CaBr_2 + HgO + H_2O \qquad (9)$$

$$HgO \rightarrow Hg + \frac{1}{2}O_2 \qquad (10)$$

$$H_2O \rightarrow H_2 + \frac{1}{2}O_2$$

Other examples of thermo-chemical cycles for hydrogen production can be found in the literature cited. An important factor to be considered in thermo-chemical processes is the recovery of the reagents or the intermediary chemicals. It is estimated that in each chemical cycle, recovery yields of 99.9 or even 99.99% have to be achieved if the thermo-chemical processes are to be viable [11].

If solar energy is first converted into electricity, then water can be electrolyzed to produce hydrogen. Hence, this process is especially suited for coupling with ocean-thermal, wind, hydro, and photovoltaic forms of solar energy since in these cases solar energy is usually (or always) converted to electricity [12].

In the photolytic reaction, the sun's photons, under certain circumstances, can be absorbed by water molecules, and when the energy absorbed reaches a certain level (68.3 kcal/mole of water), hydrogen can be released.

Solar energy can also be used in the anaerobic fermentation process of algae for the production of methane (CH_4). Methane is stable at room temperature, but can react with oxygen to produce high temperatures, while releasing its stored energy [13].

$$CH_4 + 2\ O_2 \rightarrow 2H_2O + CO_2 + \text{energy} \qquad (11)$$

Some photo-chemical reactions produce methane as an end product. One such reaction is the dissociation of H_3CHO under the influence of light, producing methane and carbon dioxide.

Other reactions might lead to other fuels (such as hydrazine, NH_2NH_2), unsaturated hydrocarbons (such as ethylene), or saturated hydrocarbons of higher order than methane (C_2H_{2n+2}).

4. COMPARISON OF STORAGE SYSTEM TYPES

The main problem with water-storage systems over long operation periods is corrosion. Another disadvantage of water-storage systems is that the volume of the storage medium can be very large for large heat capacities and, therefore, the whole system becomes very heavy. With large storage units, there is also the problem of maintaining thermal stratification, and because of this, controls are required.

With packed-bed storage systems there are no corrosion and scale-forming problems, but the volume of the system increases with related increases in cost. On the other hand, by the use of phase-change storage systems the large volumes required by the other two types are eliminated. Because of the chemical interaction of the storage material and the container, the storage material looses its energy-storage characteristics after a period of time.

In Table 6, a comparison of the above three systems are given for 10^6-kJ capacity with a 40 °C temperature difference. It is assumed that containers of phase-change systems are manufactured using plastics and the deformation of the material will begin only after five years [14].

As seen from Table 6, the most economical type system is the water-storage system. On the other hand, water-storage-systems occupy a volume 80 times larger than the volume occupied by phase-change systems, and they have an amortization period which is four times greater than the amortization period of phase-change systems.

Table 6: Comparison of storage systems for 10^6 kJ capacity* and temperature difference of 40 C° [14]

Type	Total Cost Turkish Lira	Amortization Period Years	Yearly Investment with 15% Interest Turkish Lira/Year	Volume Occupied m^3
Phase-Change	60,000	5	17,880	3
Water	90,000	20	14,310	250
Rock-Pile	110,000	50	16,610	400

* Table is presented with 1977 market prices and average heat transfer properties. (1$ ≅ 17.5 Turkish Lira)

Rock-pile storage systems have larger amoritization periods because they have no corrosion and deformation problems, but with their volumes being large, their total initial costs are very high.

Phase-change systems are the most expensive but also the most compact. If the problems associated with these systems are solved, in the future they will be the most promising.

On a weight basis, and even on a volume basis, chemical storage has a greater capacity than other systems. High-pressure (50 atmospheres) $CO\text{-}H_2$ mixtures, for example, have a storage capacity of an order of magnitude higher than liquid water (though less than salt hydrates and much less than metal hydrides). Although adequate thermodynamic data exist for most of the chemical reactions of interest, chemical kinetic data are very sparse, even for simple systems such as the methane-water system.

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From the CHARTER OF THE UNITED NATIONS UNIVERSITY

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2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

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Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811   Telex: J 25442
Cable: UNATUNIV TOKYO

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ON NEW AND RENEWABLE SOURCES OF ENERGY

THE UNITED NATIONS UNIVERSITY

UNITED NATIONS CONFERENCE ON
NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

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THE UNITED NATIONS UNIVERSITY
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INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

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A. General

B. Solar Energy

- B1 Radiation Measurement
- B2 Photovoltaic Conversion
- B3 Active Thermal Systems
- B4 Passive Thermal Systems

C. Bioconversion Energy

- C1 Biomass Production and Conversion
- C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

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ABSTRACTS

A. GENERAL

117/81 ENERGY NEEDS, USES AND RESOURCES IN DEVELOPING COUNTRIES. P.F. Palmedo, R. Nathans, E. Beardsworth and S. Hale, Jr. (Policy Analysis Division, National Center for Analysis of Energy Systems, Brookhaven National Laboratory, Upton, NY (USA)). BNL-50784 (March 1978) 143p. NTIS. US$11.50.

This report identifies the energy needs, uses and resources in the non-OPEC industrially developing countries of the world and examines the energy options available to them for their continued economic growth. If traditional patterns of development continue, oil consumption in these countries will grow steadily, and will become comparable with current US consumption between 2000 - 2020. Attempts to exploit indigenous hydrocarbon resources, even in those countries with untapped reserves, will be limited by shortages of capital and technically oriented manpower. In the absence of major efforts to replace non-commercial fuels or to increase the effectiveness with which they are used, a large fraction of the 3-4 billion Third-World rural population in the year 2000 will not be able to raise their energy usage above a subsistence level. There is a wide variety of possible solutions to these problems, many of them emerging directly from the changing economics of energy. In virtually all energy-conversion and -utilization processes, there are opportunities for improvements in efficiency and for substitution of renewable energy forms. 61 refs.

118/81 SOLAR PERSPECTIVES: NEW WORLD BRAZIL, ENERGY LEADER. S. Winsberg. Sunworld, vol. 4, no. 4, p. 139-43 (1980).

This article describes the various efforts by Brazil to meet its energy needs through the use of locally available resources. The government has launched a renewable-resource programme emphasizing energy self-sufficiency through the development of hydropower, alcohol, and solar energy processes. Details of all three efforts are included and opportunities that have presented themselves for international co-operation are outlined. The author feels that renewable resources are increasingly the basis for Brazil's future prosperity and expects Brazil to even export such technology to other industrially developing nations.

119/81 RELEVANCE OF ENERGY TO THE AGRICULTURAL SECTOR. D. Pimentel and M. Pimentel (College of Agricultural and Life Sciences, Cornell University, Ithaca, NY (USA)). P. 48-66 of Caribbean Consultation on Energy and Agriculture (Consulta del Caribe sobre Energía y Agricultura). Instituto Superior de Agricultura, Santiago, Chile (1980).

Most of the world's arable land is in use and little additional land will become available for crop production. The only way to increase crop yields on this limited land is to increase the use of fertilizers, pesticides, irrigation, and other essential inputs. All these inputs depend upon fossil energy, a resource that not only is finite, but one that is rapidly being depleted. It is hoped that new energy sources will soon become available. No one resource will satisfy the future needs of the world, and new energy sources will be significantly more costly than fossil energy. Perhaps their environmental effects will even present serious problems. The challenge is to find ways to successfully solve the population and food dilemma given the carrying capacity of the earth for man and his essential ecosystem. 17 refs.

120/81 ENERGY RELATED ACTIVITIES OF THE WORLD BANK. V.J. Riley (World Bank, Washington, DC (USA)). P. 121-3 of Proceedings of the Department of Energy Solar Export Opportunities Workshop (held Atlanta, GA, USA, 8 Jan. 1979). SERI/TP-49-186 (1979). NTIS. US$11.50.

The World Bank is an international organization, a specialized agency of the UN which finances projects in industrially developing countries involving agriculture, power generation and distribution, and industry. Many solar technologies which are already well established (biomass, wind-energy systems, water heaters, etc.) are discussed. The development and application of some other technologies that are (or have the potential of becoming) economically feasible in the near or medium future are investigated. These include solar pumps, solar-electric power, and other devices capable of playing a role in the developing world, particularly devices with potential as a decentralized source of energy on farms and in small communities in rural areas. Some specific programmes being undertaken are cited.

121/81 NATURAL ENERGY SOURCES AND AGRICULTURE. J. Uchijima (National Institute of Agricultural Sciences, Tokyo (Japan)). Nōgyō Oyobi Engei (Agriculture and Horticulture), vol. 54, p. 109-16 (1979). In Japanese.

The relations between natural energy sources (solar, wind, and biomass) and agriculture are described, and distribution figures are given for Japan. The importance of the inclination of solar radiation related to agriculture is also emphasized. The biomass produced by forests in Japan is 3.14×10^{15} kcal/y. The unrestricted utilization of this energy causes deficiencies of organic substances in the soil and will results in future production difficulties. 18 refs.

B. SOLAR ENERGY

122/81 HARNESSING THE MIDEAST SUN. R.G. Khouri, Sunworld, vol. 4, no. 4, p. 122-5 (1980).

This article describes the solar energy programme in Jordan which is co-ordinated by the Mechanical Engineering Department of that nation's Royal Scientific Society. The main efforts are directed toward desalination, domestic water heating, and space heating and cooling. In addition, work is being undertaken in the field of telecommunications, greenhouse cultivation, and solar mineral extraction using evaporation ponds.

123/81 SOLAR ENERGY PROGRAMME AT THE INSTITUTE OF ENGINEERING OF THE NATIONAL UNIVERSITY OF MEXICO. R. Almanza, J.L. Fernandez and F. Munoz (Universidad Nacional Autónoma de México, Mexico 20 D.F. (Mexico)). P. 2013-6 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, WA, USA (1979).

The research programmes at the University of Mexico are reviewed. Topics include: the production of mechanical energy and electricity using thermodynamic processes; the use of solar energy for drying cereal grains; different types of water heaters; and solar cookers. 6 refs.

124/81 SUN ARCHI (ARCHI DE SOLEIL). P. Bardou and V. Arzoumanian. Parenthèses, 13360 Roquevaire, France (1978) 120p. In French.

This book describes and illustrates a new concept for solar architecture. It begins by describing the importance of climatic conditions and then describes the physical and thermodynamic requirements for human habitation. This is followed by an extensive chapter on solar architecture and design. 20 case studies are examined with 3 concentrating on integrated architecture designs. 243 refs.

Cet ouvrage décrit et illustre les conceptions nouvelles en matière d'architecture solaire: importance des conditions climatiques, contraintes physiques et thermodynamiques propres au logement. Chapitre détaillé sur les techniques et les formes de l'architecture solaire. 20 études de cas, dont trois mettent spécialement l'accent sur l'intégration des divers procédés. 243 réf.

125/81 SOLAR TECHNOLOGY: FUNDAMENTALS, APPLICATIONS, AND FUTURE OUTLOOK (SOLAR TECHNIK: GRUNDLAGEN, ANWENDUNGEN UND ZUKUNFTSAUSSICHTEN). G. Lehner, H. Birnbreier, W.H. Bloss, R. Buhs, B. Dietrich, E. Hahne, G. Hewig, H. Hopmann, F. Reinmuth and K. Schreitmüller. Lexika Grafenau, Fed. Rep. of Germany (1978) 178p. In German.

This book is the 21st volume of the series "Kontakt und Studium" (Contact and Studies). This series is somewhat a "modern encyclopedia" of selected topics. The volume considered deals with questions of applying solar energy for contending with energy bottle-necks. The following areas of solar energy utilization are discussed: (1) possibilities of utilization, (2) solar radiation, (3) flat-plate collectors, (4) concentrating collectors, (5) heat storage in solar energy systems, (6) solar energy utilization in architecture, (7) solar houses, (8) solar thermal-electricity generation, (9) silicon solar cells and generators, and (10) thin-layer solar cells.

126/81 POWER GENERATION AND POTABLE WATER RECOVERY FROM SALINOUS WATER. D.B. Carson (to UOP Incorporated). US Patent 4,121,977 (24 Oct. 1978). File date: 16 Dec. 1976. 18p.

A process for simultaneously generating power and recovering potable water from a source of saline water (sea water) is described. Saline water which is proximate to the surface and at a relatively high temperature (about 29 °C) is increased in temperature via indirect contact with vapour (derived from the surface water at an elevated temperature and a sub-atmospheric pressure). The preheated saline water is exposed to radiant solar energy, in a solar-radiation heat sink, to further increase its temperature. Thus heated, it is introduced into a first flash-separation zone (maintained at sub-atmospheric pressure) to provide a first substantially non-saline vapour and a first saline liquid. The first vapour is passed into and through a turbine, resulting in power generation. The first liquid is then introduced into a second flash-separation zone (maintained at a lower absolute pressure than the first flash zone) to provide a second saline liquid and a second substantially non-saline vapour. The latter is utilized to preheat the saline surface water prior to the introduction thereof into the solar-radiation heat sink. The second liquid is introduced into a third flash-separation zone, to provide a third saline liquid and a third substantially non-saline vapour. Vapours exiting from the turbine and the third vapour state are cooled and/or condensed via indirect contact with a second portion of the saline water (obtained from a locus substantially lower than the surface, and at a comparatively lower temperature, about 21 °C) to recover liquid potable water. The third saline liquid is returned to the original source of the saline water.

127/81 LOW COST ELECTROLESS NICKEL BLACK COATINGS FOR PHOTOTHERMAL CONVERSION. S.N. Kumar, L.K. Malhotra and K.L. Chopra (Thin Film Laboratory, Department of Physics and Centre of Materials Science and Technology, Indian Institute of Technology, New Delhi 110016 (India)). Solar Energy Materials, vol. 3, p. 519-32 (1980).

An economically viable electroless process, different from the conventionally used chemical-conversion methods, has been developed to deposit nickel black on galvanized iron. Coatings with an integrated absorptance (α) lying between 0.90 - 0.93, a total emittance (at 100 °C) of 0.073 to 0.1, and stable up to 200 °C have been obtained. The coatings contain Ni and Zn particles embedded in a suitable matrix of NiO, Ni_2O_3 and Ni_7P_3. The coatings contain practically no sulphides and hence are less susceptible to humidity-degradation processes. 9 refs.

128/81 OPTICAL AND ELECTRICAL INVESTIGATIONS ON ANNEALED INDIUM OXIDE SELECTIVE COATINGS PRODUCED BY SPRAY PYROLYSIS. A.K. Sharma, B.K. Gupta, S.S. Mathur and O.P. Agnihotri (Indian Institute of Technology, New Delhi (India)). P. 119-21 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

Starting from indium, transparent conductive coatings of indium oxide have been produced by spray pyrolysis. Optical-extinction coefficients, transmission coefficients, and refractive indices were determined as a function of annealing temperature and sheet resistance. The conduction mechanism in these coatings involves oxygen or anion vacancies. These vacancies are incorporated during the annealing of the films in the oxygen-free environment. A 300 °C anneal is the best for large index and high conductivity and transmission coefficients for over 90% of the entire visible region. Annealing is found to extend the absorption edge to shorter wavelengths. The coatings have good adherence and withstand cleaning, heating, polishing and bonding without failure.

129/81 POSSIBILITY OF BLACK ZINC OXIDE AS SPECTRALLY SELECTIVE COATING FOR LOW TEMPERATURE SOLAR COLLECTORS. M. Van Der Leij. Journal of the Electrochemical Society, vol. 125, no. 8, p. 1361-4 (Aug. 1978).

The effects of different process parameters and aging tests on the solar absorptivity and the thermal emissivity are discussed for zinc oxide coatings. In general, most of the zinc oxide coatings investigated had a black colour and mirror-like appearance. The blackness was not uniform and some of the surfaces showed tiny white sparsely spread dots (perhaps white zinc oxide or Zn) which were not affected by the anodic treatment. The best spectrally selective surface, taking into account corrosion-resistance considerations and thermal and ultraviolet stability, appears to be zinc oxide on polished leaf-Zn prepared by anodic treatment of the substrates in a solution containing 30 g/l NaOH, 20 g/l $NaNO_3$ and 5 g/l $NaClO_2$ at 40 °C bath temperature with 20 (AC) A/dm^2 for 1 minute or slightly longer treatment time. 9 refs.

130/81 SELECTIVE SURFACES FOR COPPER SOLAR ABSORBERS. R.S. Lindstrom, R.L. Merriam, E.H. Newton and G. Cypher. P. 113-5 of Proceedings of the American Electroplaters' Society Coatings for Solar Collectors Symposium (held Atlanta, GA, USA, 9 Nov. 1976). American Electroplaters' Society, Winter Park, FL, USA (1976).

Copper has long been recognized for its outstanding durability. As a result, it is being used with increasing frequency as an absorber in low-temperature flat-plate solar energy collectors. To enhance the utility of copper absorbers, INCRA has sponsored development of low-cost durable selective surfaces. Of the commercially available and experimental surfaces evaluated, thin copper oxide coatings were the most promising. Significant improvements in durability have been obtained by applying coatings with inhibitors to the oxide and other selective surfaces. Long-life tests have not yet been completed.

131/81 DIRECT PHOTOELECTROCHEMICAL CONVERSION AND STORAGE OF SOLAR ENERGY. P.N. Moorthy, M.D. Karkhanavala and P.V. Kamat (Bhabha Atomic Research Center, Bombay (India)). Vol. 2, p. 808-13 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon Press, Elmsford, NY, USA (1978).

The performance in direct sunlight of a photo-electrochemical cell employing an n-type TiO_2 film as the photoanode, a graphite rod as the cathode and air-saturated NaOH as the electrolyte has been studied. Over a period of several days its output was found to remain stable, depending only on the intensity of incident sunlight, and there was no measurable chemical change in the electrolyte or the electrode. The power-conversion efficiency was found to be a maximum at 1/5th the maximum incident sunlight intensity (110 mW cm^{-2}). One of the possible causes of reduced efficiency at higher intensities is inferred to be the slowness of the cathodic reaction. It has been shown that energy storage, both internally (in a suitable redox system) and externally (in conventional lead-acid accumulators) is feasible. 6 refs.

B1. Radiation Measurement

132/81 EXPERIMENTAL INVESTIGATION OF AN INEXPENSIVE SKY TEMPERATURE MEASURING DEVICE. S. Karaki and P. Brothers (Solar Energy Applications Laboratory, Colorado State University, Fort Collins, CO (USA)). COO-4522-1 (Aug. 1979) 22p. NTIS. US$7.50.

The objectives were to develop a simple approach for determining the clear-sky temperature from the ground air temperature and the absolute humidity and to develop an inexpensive device for its direct measurement. The analytical approach taken was similar to that developed by Bliss. A simple device to measure sky temperature was designed and tested but development efforts within the means of the project were unsuccessful. It was concluded that a device that could include measurements (or knowledge) of the convective heat-transfer coefficient rather than control or elimination of it would be an alternative approach in the development of a sky-temperature measurement device.

B2. Photovoltaic Conversion

133/81 THE PHYSICS AND CHEMISTRY OF SOLAR CELLS. K.W. Böer (College of Engineering, University of Delaware, Newark, DE 19711 (USA)). Journal of Photochemistry, vol. 10, p. 77-110 (1979).

This article describes the theory of physical and chemical phenomena occurring in the conversion of solar energy into electricity using solar cells. Emphasis is placed on $Cd_xZn_{1-x}S-Cu_2S$ cells. 52 refs.

134/81 MIS SOLAR CELLS: A REVIEW. D.L. Pulfrey. Institute of Electrical and Electronic Engineers Conference on Transactions on Electron Devices, vol. ED-25, no. 11, p. 1308-17 (1978).

MIS structures can control not only the magnitude of the dark current flowing in a diode using a thin insulating layer but also the main component of this electric current (i.e. either the minority or the majority carrier). This paper is concerned with the above as well as the use of models to explain the increase in photovoltage of a practical Si cell and a GaAs MIS cell and to investigate the main factors influencing the static characteristics of solar cells (including the photocurrent, fill factor and conversion efficiency) in order to obtain the parameters which limit the characteristics of present devices. Future prospects for the open-circuit voltage, short-circuit current density, fill factor, and efficiency of these cells as well as the present status of the characteristics and technical development of MIS solar cells made from non-single-crystal substrates are examined. 63 refs.

135/81 RECENT DEVELOPMENTS IN AMORPHOUS SILICON SOLAR CELLS. D.E. Carlson (RCA Laboratories, Princeton, NJ 08540 (USA)). Solar Energy Materials, vol. 3, p. 503-18 (1980).

This article reviews recent advances in the development of amorphous-silicon solar cells. Both glow-discharge deposition conditions and the solar-cell structures are discussed in some detail. The performance characteristics of present amorphous-silicon cells are described, and the loss mechanisms that limit performance are considered. An effort has been made to point out those areas where further research is needed. Recently, amorphous-silicon p-i-n cells with areas of 1.19 cm^2 have been fabricated with conversion efficiencies as high as 6.1%. 73 refs.

136/81 EPITAXIAL SILICON GROWTH FOR SOLAR CELLS. FINAL REPORT. R.V. D'Aiello, P.H. Robinson and D. Richman (RCA Laboratories, Princeton, NJ (USA)). DOE/JPL-954817 (Apr. 1979) 64p. NTIS. US$9.50.

The objectives of this contract were: (1) to determine the feasibility of silicon epitaxial growth on low-cost silicon substrates for the development of silicon sheet capable of producing low-cost high-efficiency solar cells; (2) to achieve a goal of 12% (AM0) efficient solar cells fabricated on thin epitaxial layers (<25 µm) grown on low-cost substrates; and (3) to evaluate the add-on cost for the epitaxial process and to develop low-cost epitaxial-growth procedures for application in conjunction with low-cost silicon substrates. The basic epitaxial procedures and solar-cell fabrication and evaluation techniques are described, followed by a discussion of the development of baseline epitaxial solar-cell structures, grown on high-quality conventional silicon substrates. This work resulted in the definition of three basic structures which reproducibly yielded efficiencies in the range of 12 to 13.6%. These epitaxial-growth procedures and baseline structures were then used to grow diagnostic layers and solar cells on four potentially low-cost silicon substrates. A description of the crystallographic properties of such layers and the performance of epitaxially grown solar cells fabricated on these materials is given. The major results were the achievement of cell efficiencies of 10.6 to 11.2% on multigrained substrates and approximately 13% on a low-cost single-crystal substrate. An advanced epitaxial reactor, the rotary disc, is described. The results of growing solar-cell structures of the baseline type and on low-cost substrates are given. The add-on cost for the epitaxial process is assessed. These cost estimates show a value of approximately US$0.46/W using existing or near-term technologies and project an add-on cost of US$0.10/W for future reactors.

137/81 DEVELOPMENT OF SILICON SOLAR CELLS FOR CONCENTRATED SUNLIGHT. S.P. Joshi, R. Lahri, S.K. Goel and T.K. Bhattacharya (Central Electronics Ltd., Sahibabad (India)). P. 292-5 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

The design, fabrication and performance data of silicon n^+-p-p^+ solar cells for concentrated sunlight (30x AM1) are presented. These cells exhibit a total-area efficiency in excess of 11% up to 30x AM1 illuminations. The effects of increasing sunlight concentration on various solar-cell parameters like the open-circuit voltage (V_{oc}), short circuit current (I_{sc}), internal series resistance (R_s), fill factor (FF), and efficiency (η) are also studied.

138/81 CASCADE SOLAR CELLS. M.F. Lamorte (to Research Triangle Institute). US Patent 4,179,702 (18 Dec. 1979). File date: 9 Mar. 1978. 12p.

A monolithic cascade cell for converting incident radiation, particularly solar radiation, into electrical energy at a high efficiency with at least three layers of semi-conductive Group III-IV material is described. The top layer is doped into p and n regions with a homojunction therebetween and has a bandgap such that photons above a predetermined energy interact with the semi-conductive material to produce a potential across the homojunction and current flow. Photons below that energy pass through the first layer to a second similar layer having a lower bandgap so that some of the radiation passing through the first layer produces a potential across a homojunction in the second layer to improve the overall energy-conversion efficiency of the cell. The first and second layers are separated by at least a third layer of a Group III-V material, similarly doped into p and n regions with a tunnel junction formed therebetween to provide a low-voltage electrical connection between the first and second layers. In one embodiment, the first and second layers are connected in series to be additive so that current flow takes place between contacts associated with the first and second layers. In another embodiment, the first and second layers are connected in opposition with a third terminal connected to the third layer which, in this case, need not be a tunnel junction. Alternatively, the two layers may be light-producing devices such as light-emitting diodes (LEDs), emitting light at different wavelengths, or photodiodes, detecting light of different wavelengths, or one layer can be a light-producing device such as an LED while the other layer is a light-receiving device such as a photodiode, again operating at different wavelengths.

139/81 PERFORMANCE OF SILICON AND GALLIUM ARSENIDE CONCENTRATION CELLS. D.T. O'Donnell, S.P. Robb, T.T. Rule, R.W. Sanderson and C.E. Backus (Arizona State University, Tempe, AZ (USA)). P. 804-9 of Proceedings of the IEEE Photovoltaic Specialists Conference (held Washington, DC, USA, 5 June 1978). Institute of Electrical and Electronics Engineers, Inc., New York, NY, USA (1978).

Several organizations are currently developing cells that are especially designed for concentrated-sunlight conditions. Preliminary cells from five different organizations have been tested. Performance as a function of solar intensity as well as increasing temperatures has been measured. Many of the silicon cells have peak efficiencies in the 15-18% range. One Si cell tested maintained an efficiency of over 17% up to 400 suns. The peak efficiency of the GaAs cell tested was 21.7%.

140/81 SINTERED TYPE CADMIUM SULPHIDE-THALLOUS SULPHIDE HETEROJUNCTION PHOTOVOLTAIC CELLS. M.J. Chockalingam, K. Nagaraja Rao, N. Rangarajan and C.V. Suryanarayana (Central Electrochemical Research Institute, Karaikudi (India)). P. 376-738 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Cadmium sulphide powder was prepared by a chemical method. To this powder, fluxing material and dopants were added in the required proportions and a slurry was prepared using a combination of non-aqueous solvents. By using a silk-screening technique, several conducting substrates were coated with this slurry. Sintering was carried out in controlled atmospheric conditions around 600 °C. On the sintered layer, a thallous sulphide p-type layer was applied by a chemical-deposition technique. The whole assembly was heat-treated and a heterojunction was formed between n-type cadmium sulphide and p-type thallous sulphide. The characteristics of the cells were studied.

141/81 EFFECT OF HEAVY DOPING ON THE PROPERTIES OF HIGH-LOW JUNCTION. A. Sinha and S.K. Chattopadhyaya (Kurukshetra University, Haryana (India)). Institute of Electrical and Electronic Engineers Conference on Transactions on Electron Devices, vol. ED-25, no. 12, p. 1412-4 (Dec. 1978).

The minority-carrier reflecting properties of the high-low junction were studied, taking into account heavy-doping effects. It was observed that the junction-leakage velocity obtained a minimum value for a particular impurity concentration in the heavily doped region. In this study, an empirical relationship giving the bandgap narrowing as a function of the impurity concentration in silicon was utilized. 16 refs.

142/81 A NOVEL SQUARE FRESNEL LENS DESIGN FOR ILLUMINATING CIRCULAR SOLAR CELLS. E.L. Burgess, D.L. Marchi and H. Walter. Optical Engineering, vol. 17, p. 299-300 (1978).

This new square Fresnel lens can focus radiation at high densities on many photovoltaic arrangements, and can decrease system costs to a minimum. This new design uses a focal point related to the corner of the Fresnel lens which is different from that originating from the central part. An acrylic lens has been produced by compressing a suitable material in a metalic mold. This lens has a transmission efficiency of 79.4% within the spectral range utilized by solar cells.

143/81 PHOTOTHERMAL CONVERSION OF SOLAR ENERGY INTO ELECTRICITY. J.A. Moragues (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). DOE-TR-159 (1978) 37p. NTIS. US$8.50.

Brief descriptions of various collectors that can be used in the solar photo-thermal conversion process for producing electricity are given, including: solar stills, shallow solar ponds, flat-plate collectors, fixed collectors with moderate concentration, cylindrical parabolic concentrators, fixed concentrators with a faceted mirror, concentrators with concave rotating multiple mirrors, Fresnel lenses, paraboloidal rotating concentrators, semispherical fixed concentrators, a central receiver system with a linear focus, and a central receiver system with a point focus. Other topics include thermodynamic cycles, energy transport, energy storage, and economics. A review of some of the programmes throughout the world for development of solar-thermal power conversion is included.

B3. ACTIVE THERMAL SYSTEMS

144/81 ANALYTICAL AND EXPERIMENTAL STUDY OF PUMPED SOLAR WATER HEATERS. B. Nimmo (University of Petroleum and Minerals, Dhahran (Saudi Arabia)), J. Pearce and W. Clark. Vol. 2, p. 907-11 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon Press, Elmsford, NY, USA (1978).

The results of an analytical and experimental study of forced-circulation solar water heaters are presented and discussed. A computer model which allows for fluctuating insolation, changing ambient temperatures, and the withdrawal of hot water at random times, has been developed. This system model has been successfully used to predict the performance of an installed forced-circulation solar water heater under in-use conditions and experimental data for such a system are presented. They include environmental operating conditions (such as insolation and ambient temperatures) and hot-water load draw off data. Results are shown for predicted and experimental collector inlet and outlet temperatures. The percent load carried by solar energy during each day of a week of operation is also given. 10 refs.

145/81 A LOW LIFT SOLAR WATER PUMP. M.P. Sharma and G. Singh (Agricultural and Food Engineering Division, Asian Institute of Technology, Bangkok (Thailand)). Solar Energy, vol. 25, p. 273-8 (1980).

A model of a diaphragm pump using an automatic-valve mechanism consisting of a set of permanent magnets and springs was developed for low-lift solar water pumping. The pump that has been developed is based on the thermodynamic-conversion method using an intermittent Rankine cycle with freon-113 as a working fluid. Solar radiation collected on a simple flat-plate solar collector (size 1.4 m^2) is used to vaporize the liquid freon. The vapour pushes a rubber diaphragm which in turn pumps the water. The exhaust vapour is condensed and collected in a container. The condensate is charged into the flat-plate solar collector by gravity for use during the next day's operation. Test results showed that with a constant input vapour pressure the discharge of the pump decreased as the head increased. The discharge of the pump was 4.3 l/min at a 3-m head while it reduced to 2.8 l/min at a head of 6 m with a freon pressure of 2.4 mg/cm^2 (240 kN/m^2) inside the collector. The head increased as the input vapour pressure increased. 6 refs.

146/81 DEVELOPMENT AND TESTING OF AN AMMONIA-WATER ABSORPTION REFRIGERATION SYSTEM FOR A COLD STORAGE UNIT USING SOLAR ENERGY. S.P. Sukhatme, S.G. Kandlikar, G.K. Sadekar and S.H. Bhavnani (Indian Institute of Technology, Bombay (India)). P. 193-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

A continuous-cycle ammonia-water absorption-refrigeration system was designed and fabricated for refrigerating a cold storage unit. The temperature to be maintained inside the cold unit was 5 °C, and the refrigeration capacity was 0.5 tonne. Hot water from solar collectors (flat-plate collectors with mirror boosters) was supplied at 95 °C through a storage system. Provision for auxiliary electric heating was also made. Development, testing and preliminary performance studies on the refrigeration system are reported.

147/81 SANDIA LABORATORIES OPERATIONAL EXPERIENCE WITH SMALL HEAT ENGINES IN SOLAR THERMAL POWER SYSTEMS. (Sandia Laboratories, Albuquerque, NM (USA)). Proceedings of the Fourteenth Intersociety Energy Conversion Conference (held Boston, MA, USA, 5 Aug. 1979). SAND-78-2163C (1979) 5p. NTIS. US$7.50.

During the time that Sandia Laboratories has been engaged in solar energy research and development, a significant amount of hardware and operating experience has been obtained from the construction and testing of 2 small Rankine-cycle solar-thermal power plants. The first plant is part of a prototype solar total-energy system with an electrical-generating capacity of 32 kW, and the second plant is part of 4 prototype solar irrigation units with a shaft power output of 19 kW or an electrical output of 15 kW. The energy-conversion hardware is described, and the performance and operating experience with the units are summarized.

148/81 UTILIZATION OF HOLLOW SLABS IN HEATING AND COOLING OF BUILDINGS. A. Kumar, A. Srivastava and G.N. Tiwari (Indian Institute of Technology, New Delhi (India)). P. 181-6 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

The thermal performance of a double hollow concrete slab in the heating and cooling of a building (whose one face is exposed to solar radiation and ambient air while the other one is in contact with room air at constant temperature) is presented. A blackened network of pipes is laid on the top surface of the roof and suitably glazed. The flow rate of water or air through the pipes is kept constant. The heat flux inside the room is reduced appreciably for higher flow rates of water. The effects of a water film on the performance of the wall or roof are also discussed.

149/81 SELECTIVE COATING FOR SOLAR WATER HEATERS. A. Chandra (Central Building Research Institute, Roorkee (India)). Vol. 1, p. 244-7 of Proceedings of the International Conference on Solar Building Technology (held London, UK, 25 July 1977). C. Stambolis (ed.). RIBA Publications, London, UK (1978).

Selective coatings can increase the efficiency of many optical systems. Two types of coatings discussed are NiS-ZnS and copper oxide layers on aluminium plates. The solar absorptance (α) of both are 0.94 and 0.88 whereas the thermal emittance (ε) is 0.15 and 0.20 respectively. The maximum exit-water temperatures for NiS-ZnS coated and copper oxide coated solar water heaters are 85 and 77 °C, respectively. 3 refs.

150/81 TUBULAR SOLAR COLLECTOR. P.K.C. Pillai and R.C. Agarwal (Indian Institute of Technology, New Delhi 110029 (India)). Applied Energy, vol. 6, no. 2, p. 125-32 (1980).

The design and construction of a low-cost solar collector, which uses a black spiral plastic tube as the absorber, is described. The efficiency of this collector is compared with other collectors. 13 refs.

151/81 NON-TRACKING MODERATELY FOCUSING HEAT PIPE SOLAR COLLECTOR. C.C. Roberts, Jr. (Packer Engineering Association, Naperville, IL (USA)). P. 114-22 of Proceedings of the Third Heat Pipe Conference (held Palo Alto, CA, USA, 22 May 1978). American Institute of Aeronautics and Astronautics, Washington, DC, USA (1978).

A design for a moderately focusing heat-pipe solar collector is presented that incorporates advantages of both flat-plate and concentrating collectors. This collector is utilized primarily for heating, has a heat-pipe absorber and uses the thermal-diode effect of the heat pipe to prevent nocturnal heat losses. A prototype collector was constructed and tested using four gravity-assisted heat pipes. The concentration ratio was 3.31 to 1. Test data demonstrated collector efficiencies near 60% at a low loss factor. Absorber temperatures ranged from 40 to 55 °C.

152/81 ENERGETIC EFFICIENCY OF SOME PARTICULAR TYPES OF FLAT PLATE COLLECTORS. J. Brodin, Van Vui Pham and C. Sinnasse (CNRS, Toulouse (France)). Vol. 1, p. 263-78 of Solar Technology for Building (Proceedings of the International Conference on Solar Building Technology, held London, UK, 25 July 1977). C. Stambolis (ed.), RIBA Publications, London, UK (1978).

The main characteristics of flat-plate collectors were outlined. The greenhouse effect was also studied, and the relations between the energetic efficiency and the solar flux were formulated. Experimental results were then analysed by the segment synthesis method to take into account the cumulative effects of the energy. Thus, the evolution of the quasistatic parameter and the energetic efficiency could be shown. The results obtained agreed with a theoretical analysis. During the period of July-September 1976, a heat gain of about 2000 kcal/m^3 per day at a temperature of 50 °C was obtained for the Toulouse region.

153/81 EXPERIMENTAL AND THEORETICAL PERFORMANCE STUDY OF SOLAR COLLECTORS. A.E. Dabiri, G. Grossman and F. Bahar (Arya Mehr University of Technology, Tehran (Iran)). P. 829-38 of Energy Conservation in Heating, Cooling and Ventilating Buildings: Heat and Mass Transfer Techniques and Alternatives (Proceedings of the Conference on Heat and Mass Transfer in Buildings, held Dubrovnik, Yugoslavia, 29 Aug. 1977). C.J. Hoogendoorn and N.H. Afgan (eds.), Hemisphere Publishing Corp., Washington, DC, USA (1978).

Performance studies of four types of solar collectors have been made to determine their adaptability for domestic water- and space-heating systems in Iran. Flat-plate collectors with various forms of plate designs and a parabolic-type concentrating collector were considered. A specially designed test facility was erected where the collectors could be tested under steady-state conditions. Flow rate, temperature and solar-radiation measurements allowed for calculations of collected energy and efficiency. A numerical model has been developed to calculate heat losses from the collectors and to predict their performance. Experimental results are given and compared with the theoretical ones obtained from a numerical analysis. Performance characteristics, including collected heat and efficiency, are calculated.

154/81 PRELIMINARY RESULTS FROM A TEST ARRAY OF 3X CPC COLLECTORS IN A SCHOOL HEATING APPLICATION. W. Zitek (University of Chicago, Chicago, IL (USA)). Vol. 2.1, p. 347-51 of Solar Diversification (Proceedings of the Meeting of the American Section of the International Solar Energy Society, held Denver, CO, USA, 28 Aug. 1978). K.W. Böer and G.E. Franta (eds.), American Section of the International Solar Energy Society, Newark, DE, USA (1978).

An array of 56 two-trough compound parabolic concentrator (CPC) solar-collector modules has been installed on the roof of an elementary school on the Navajo Indian reservation near Gallup, New Mexico, USA. The array represents an effective net collecting area of 72.9 m^2 and has been fully instrumented to provide a data base for analysing CPC collection characteristics. This is the first quantitative field test of these collectors conducted anywhere. The basic collector design is a 3X CPC matched to a finned tubular absorber with an acceptance half angle of ± 18°, allowing collection for half a year without adjustment. Very preliminary results from late spring are reported.

B4. Passive Thermal Systems

155/81 PORTABLE SOLAR GAIN DRYER. S.M. Ilyas and G.T. Kurup (Central Rice Research Institute, Cuttack (India)). P. 273-9 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

It was observed that thin aluminium collectors give the best efficiency for grain drying, and that the corrugated galvanized iron flat-plate collector is also well suited for this purpose. The efficiency can be increased by increasing the air-flow rate and covering the top surface with polyethylene or glass. This dryer was tested for paddy grain.

156/81 COMPUTER MODELING OF A VENTILATED TROMBE WALL - WITH ACTUAL PERFORMANCE RESULTS. F.V. Robbins and C.K. Spiliman (Agricultural Engineering Department, Kansas State University, Manhattan, KS 66502 (USA)). Solar Energy, vol. 25, p. 207-13 (1980).

A mathematical simulation procedure developed for use with a digital computer to predict the daily performance of a ventilated Trombe Wall is described and documented with actual measured performance results. The solar collector-storage system is used to preheat the ventilating air required by animal-confinement structures, and thus reduces their demand for fossil-fuel energy. In this system, all collected energy is delivered to the heated space in the ventilating air. This air is drawn continuously through the concrete wall on its way to the building. Given hourly or daily total solar insolation on a horizontal surface and hourly or daily average ambient temperatures, the available energy at the vertical collector and the energy transmitted through the transparent covers is first determined. Then, the collection process is simulated and the total collected energy, the amount supplied to the building, and the portion retained in storage for each day is predicted. During the 1977-78 heating season, performance data for 7 periods of approximately one month each were analysed. System performance for these periods was also simulated, and the relative error between measured and simulated performance ranged from 0 to 12% with all but one month within 6%. 8 refs.

157/81 PERFORMANCE STUDY OF A SOLAR STILL IN VALENCIA (SPAIN). J. Riera, J.A. Martinez-Lozano, F. Tejerina and F. Tena (Valencia University, Valencia (Spain)). Vol. 3, p. 57-71 of Proceedings of the Second International Solar Forum (held Hamburg, Fed. Rep. of Germany, 12 July 1978). Deutsche Gesellschaft für Sonnenenergie eV, München, Fed. Rep. of Germany (1978).

The basic equations of the thermal performance of a solar still were given in previous papers. An experimental study of the solar-distillation process was carried out in Valencia. With this purpose, two different stills were constructed, one of them provided with a floating absorber. A relationship between production and some other parameters was deduced, leading to an annual production estimation for Valencia.

158/81 TEST RESULTS FOR A COMBINATION DISTILLING UNIT. B.M. Achilov, S. Kakharov, T.O. Zhuraev and E. Norov (Bukhara Pedagogical Institute, Bukhara, Uzbek SSR (USSR)). Applied Solar Energy, vol. 16, no. 2, p. 44-6 (1980). [English translation of Гелиотехника, vol. 16, no. 2, p. 46-8 (1980)].

The technical characteristics of distillation units employing inclined and horizontal distillation surfaces to obtain fresh water by natural freezing are given in tabular form. It is shown that these units can be utilized efficiently in water-supply systems for pastures. 4 refs.

159/81 A SIMPLE SOLAR COOKER FROM INDIA. B.D. Vaughan (MRA Centre, Panchgani, Maharashtra (India)). Appropriate Technology, vol. 6, no. 1, p. 12 (1979).

This article describes a simple solar cooker built to meet cooking requirements of poor villagers in hot arid areas of India. The construction and concept of a box-type cooker are also given.

160/81 SOLAR KITCHENS FOR INDIVIDUAL AND COLLECTIVE USE. A.K. Alimov, D.N. Alavutdinov, N.F. Ovechkin and K. Nazarov (Physico-Technical Institute, Tashkent, Uzbek SSR (USSR)). Applied Solar Energy, vol. 13, no. 4, p. 68-9 (1977), [English translation of Гелиотехника, vol. 13, no. 4, p. 68-9 (1977)].

The construction and operating principle of "knock-down" portable solar kitchens for individual and collective use are described, together with the optical-energy characteristics of various electro-polished facets for solar kitchens. With average radiation, individual solar kitchens have capacities of from 5.5 to 10 l/h of boiling water and team-size kitchens from 12 to 16 l/h.

161/81 A SOLAR HEATED DRYER FOR TIMBER. A.D.K. Hardie (International Forest Science Consultancy, Silverburn, Penicuik, Midlothian EH26 9LQ (UK)) and R.A. Plumptre. Appropriate Technology, vol. 6, no. 1, p. 4-6 (1979).

A simple solar-heated lumber dryer is described in this article. After a brief description of the principles and characteristics of the solar kiln, the design and performance of this polythene dryer (capable of holding 5.7 - 7.1 m^3 of sawn timber) is described. Two fans, driven by 0.25-kW electric motors, are used to circulate air over a black corrugated-metal absorber and through a lumber stack.

162/81 SOLAR REFRIGERATION UTILIZING ZEOLITES. D.I. Tchernev (Zeopower Co., Natick MA 01760 (USA)). P. 2070-3 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, Washington, DC, USA (1979).

The operating principles of a refrigeration system using zeolites as a solid absorber for water vapour, the working fluid, are described. This system can be used for refrigeration and ice making with high efficiency. The experimental results obtained are presented. 2 refs.

C. BIOCONVERSION ENERGY

163/81 FUELS FROM BIOMASS. COMPARATIVE STUDY OF THE POTENTIAL IN FIVE COUNTRIES: THE UNITED STATES, BRAZIL, INDIA, SUDAN, AND SWEDEN. W. Vergara and D. Pimentel (Cornell University, Ithaca, NY (USA)). Advances in Energy Systems and Technology, vol. 1, p. 125-73. P. Auer (ed.), Academic Press, Inc., New York, NY, USA (1978).

Use of biomass as a source of energy varies and depends, in part, on the level of development of the country involved. In the USA, biomass conversion accounts for about 1% of the energy supply while in the Sudan it accounts for about 65%. This report considers the feasibility of using biomass as an energy source and assesses the potential for biomass-energy conversion in each of five countries, representing five different sets of environmental and special conditions. The following aspects of biomass-energy conversion are investigated: the potential of biological materials for biomass-energy conversion; the role of both agriculture and forestry in solar energy conversion; the potential for biomass-energy conversion utilizing combustion, ethanol fermentation, anaerobic digestion, and pyrolysis; and the environmental and social constraints in biological solar energy conversion. 103 refs.

164/81 BIOSYNTHESIS OF ENZYMES BY SOLID SUBSTRATE FERMENTATION. I. PRODUCTION OF CM-CELLULASE BY Trichoderma viride. M.A. Qadeer, F.H. Shah, A. Jabbar and A. Ilahi. (Pakistan Council of Science and Industrial Research, Lahore (Pakistan)). Pakistan Journal of Scientific and Industrial Research, vol. 20, no. 2, p. 120-3 (1977).

CM-cellulase formation by growing T. viride on wheat bran, maize bran, rice husks, or bagasse was studied. Of all substrates, wheat bran was the most suitable for enzyme synthesis. The effect of various diluents was investigated, but enzyme production was maximum when an Na CM-cellulose (0.5%) + mineral salt solution was used to dilute the wheat bran or other substrate

UNCNRSE
CONFERENCE NEWS 5

UNDP STUDY FORESEES WIDER USE OF NRSE

The importance of energy as a factor in economic and social development throughout the world has been brought into sharp focus since 1973 with the escalation of conventional fuel prices. Industrialized countries have experienced inflationary pressures and strains upon their industrial structures impacting the maintenance of their economic growth paths. Developing countries have faced added strains upon their balance of payments and on their efforts to effect programmes to accelerate their economic and social progress. Virtually every country has concerned itself with the issue of maintaining and developing new sources of energy supply to achieve and sustain economic and social growth.

This concern is manifested universally by various and diverse national and international efforts to accelerate the exploration and exploitation of new sources of conventional fossil fuels. It is also evidenced in the efforts to bring about energy conservation. Finally, increasing attention has been given to the development of new energy sources, to non-conventional energy in the forms of solar, biomass, woodfuels, wind, small hydro, and geothermal. With the escalation of fossil fuel prices and the recognition of their depleting supplies, a number of activities have been initiated by countries which are proceeding to expand energy resources in all areas of technological research, conservation and new discoveries.

This summarizes, in brief, a two-volume study released by the United Nations Development Programme, entitled "Non-Conventional Energy"*. Conducted in over 100 developing countries, the study provides an assessment of the state of the art of non-conventional energy technologies, a review of the needs and prospects for non-conventional energy as developed by the UNDP Resident Representatives generally in consultation with the governments concerned, and a summary of activities to promote non-conventional energy development by international organizations and individual donor countries.

The State of the Art

The state-of-the-art section defines in part the limits within which non-conventional energy can be exploited in the near and long terms. The relative commercial readiness of emerging energy technologies is a necessary condition for the planning of energy programmes. The interests of and current state of indigenous research, development and diffusion of these systems is an indicator of the needs of the developing countries. The current levels and forms of assistance provide a basis for evaluating potential actions which could be taken to rationalize efforts to exploit non-conventional energy development by identifying what is or is not being provided.

The needs of developing countries, in particular, merit attention owing to their objectives to achieve a high and sustained rate of economic growth and, therefore, to relieve the burden on foreign exchange resources imposed by increasing imported fuel prices. The historical approach to energy planning stresses the expansion of conventional energy sources and, generally, large-scale centralized systems. Thus, many countries face the problem of unequal internal growth and, also, a disintegration of the rural and non-commercial sectors. By concentrating energy supply in the growth centres of the countries, rural sectors cannot avail themselves of the potential for more modern methods of production. These factors have evoked an interest in developing new approaches to energy planning. In response, many governments have established ministries of energy with the aim of examining the use of all and not just one energy source. This reorientation does not mean that non-conventional energy resources will be brought into use in the near term. However, it does facilitate the active consideration of non-conventional energy resources as part of the supply mix.

Even when governments are willing and eager to develop non-conventional energy sources, the study reveals that a number of practical barriers stand in the way.

Technical readiness is pointed out as the first barrier. As expected, the industrialized countries are further advanced in non-conventional energy research and development. They have better scientific bases, more resources available and the known manufacturing capability to produce these new energy systems. The study warns that this does not mean that the non-conventional energy systems designed in the industrialized countries would be necessarily appropriate or feasible in the developing world. It is essential that the developing countries mount their own scientific and production efforts in this area, and are now doing so. Of the 31 non-conventional energy technologies reviewed by this study, 12 are available for utilization in the developing world at present; 24 more should be ready for commercial use by 1990.

Other barriers mentioned are: that most of these sources are not cost-competitive with conventional fuels; that they must be socially acceptable; and that the limited reservoir of trained personnel in the developing countries hampers their capacity to construct, operate and maintain renewable energy systems.

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* Non-Conventional Energy, Volumes I and II, prepared for UNDP by PRC Energy Analysis Company.

This section of *ASSET (Abstracts of Selected Solar Energy Technology)* is devoted to the UN Conference on New and Renewable Sources of Energy and is published by the UN University with the co-operation of the UNCNRSE Secretariat and the UN Division for Economic and Social Information of DPI.

UNDP Resident Representatives Surveyed

A substantial portion of this study reviews a 1979 survey of UNDP Resident Representatives designed to assess country approaches to the energy situation and the place of renewable energy in the country contexts.

This survey cited the need for national energy planning as a major priority for developing countries. It was noted that a lack of medium and long range energy planning caused serious economic disruptions in the developing world. Only 20% of the respondents identified rural energy as the highest energy priority.

It was pointed out that generally energy conservation is not a widespread concern to developing countries. For the most part, conservation was addressed from the perspective of conventional and imported fuels. They implied that incentive schemes in the form of lower prices of non-conventional fuels or of energy systems were to be introduced. Only one country addressed conservation of traditional fuels. That most of the countries are not actively investigating conservation potential is not an indicator of disinterest. It is rather a matter of relative priorities. The governments appear to be more concerned with expanding energy production to meet the needs of economic growth.

The survey showed that more than 80% of the countries were exploiting and/or developing one or more indigenous energy resource. Most were developing more than one such conventional resource. More than two-thirds of the countries were identified as having some entity engaged in research in non-conventional energy development.

Research, demonstration-testing, and commercialization efforts have been identified in most countries. A total of 106 projects have been enumerated. 64 of the projects are research, 32 are demonstration and field testing activities, and the remainder are operational programmes.

Nevertheless, the responses to the survey contain sufficient data to draw the conclusion that the Resident Representatives and, perhaps, the governments are aware of the actions which need to be taken. In general, the types of technical assistance offered normally by UNDP would be appropriate to assist the developing countries in moving forward in the non-conventional energy sector.

International Organizations and Donor Countries in the Development of Non-conventional Energy

The records of the United Nations and the survey responses of the UNDP Resident Representatives provide considerable evidence that both international organizations and individual countries are actively involved in the development of non-conventional energy. The United Nations Economic and Social Council reports 158 different programmes undertaken by the United Nations and other agencies in the field of non-conventional energy since 1973; and the World Bank reports 51 projects in renewable energy, most of which are components of broader investment activities. The majority of the non-conventional energy projects identified by the United Nations Survey can be characterized as information development and dissemination projects. They take the form of conferences, workshops and commissioned studies.

In general, the conclusion to be drawn from this survey of UN and other assistance in the non-conventional energy field is that developing countries and organizations providing assistance have turned their attention to non-conventional energy. This focus, uniformly distributed throughout the developing world, heralds a move towards a co-ordinated approach to national energy sector planning, including renewables.

Recommendations

The study recommends measures to be taken in the field of non-conventional energy development, with possible UNDP assistance.

Priority among these was given to comprehensive assistance for energy planning encompassing conventional and non-conventional energy sources and energy conservation. It is recommended that an expert working group be convened to draft guidelines for national energy planning, and in particular, to develop techniques including training curricula, for planning.

Since information was identified as a major bottleneck in the development of energy resources, assistance should be geared towards improved collection of data and the strengthening of technical dissemination systems including technical reference libraries. Where relevant, technical meetings symposia and expert group meetings could be organized on a regional or sub-regional level to facilitate information exchange.

Technical co-operation programmes should be provided on a national or regional basis to train extension officers within ministries of energy, forestry, agriculture and community development in appropriate technologies. But in order to ensure widespread social acceptance, rural innovations should be developed with the collaboration of the affected groups. Since energy is used in many environments by women, consideration of the use of female extension officers who in principle can relate to village women should receive high priority.

Since there is a competing demand for skilled personnel in all areas of government concern, it is appropriate that a special category of fellowships be established specifically designated for the training of specialists in non-conventional energy. Similarly, vocational training schools, centres and colleges could be the subject of assistance to develop a cadre of skilled technical manpower to maintain renewable energy systems and to monitor demonstration projects.

In the area of applied technology, demonstration projects should be undertaken, including identifying sites coupled with practical training in preparing implementation plans for installation. Regional trade shows and exhibitions will enable appropriate officials of developing countries to become aware of the variety of systems being developed by different manufacturers.

The evaluation of rural electrification projects in comparison with renewable energy systems and in terms of traditional criteria should be undertaken. It is also recommended that consideration be given to the development of model standards for local, indigenous manufacturing plants.

SUMMARIES: TECHNICAL PANEL REPORTS (II)

(Continued from UNCNRSE Conference News 4, ASSET, vol. 3, no. 2)

BIOMASS ENERGY

Biomass today provides between six and thirteen percent of the world's total energy needs - an amount equivalent to some 8.5 million barrels of oil per day. It is currently the major source of energy for the half of the world's population which lives in the rural areas of developing countries. The annual productivity of biomass in forests alone has been estimated to be 74 billion tonnes per year with an energy content nearly three times greater than current global energy usage. Much of this current use of biomass consists of the burning of fuelwood and charcoal, which was discussed in detail by a separate technical panel. Future developments in biomass technology will also be particularly relevant for rural areas. Agricultural residues such as wheat and rice straws and animal manures have been estimated to be 4.2 billion tonnes annually which could supply one tenth of current global energy usage once converted into methane and carbon dioxide by the process of biomethanation.

In two meetings in 1980 a Technical Panel of 14 experts from developing countries such as Brazil, China, India, Mexico, Thailand, Tunisia and Uruguay, as well as from several industrialized countries, discussed biomass energy and noted that despite its many social and economic advantages biomass energy is an option which has received only limited attention by policy planners at the national and international levels.

Issues

The primary issues addressed by the Panel with respect to biomass energy were the availability of biomass resources, the technologies for their utilization, the potential long-term options for biomass energy production, the economics of biomass as an energy source, and the social and economic impacts of its utilization.

Biomass is not uniformly distributed over the earth's surface, and in some regions usage exceeds the supply. Excessive and random usage of biomass, especially firewood, has resulted in some regions in deforestation, erosion of lands, flooding and silting. Yet, in many areas potential biomass-energy sources are currently considered waste products whose disposal poses a problem for society. Thus, utilization of these wastes could both solve waste disposal problems and provide energy. In addition to biomass wastes, the active cultivation of energy crops - short rotation tree farming, aquatic plant farming, and vegetable-oil production - is possible in many places on land otherwise unsuitable for productive agriculture, as is the usage of standing vegetation and grasses.

The technologies for the conversion of biomass into usable energy forms fall into two categories: biological and thermochemical. Biological energy conversion entails energy yielding enzymatic breakdown of biomass by micro-organisms under anaerobic conditions. The main routes are biomethanation (anaerobic digestion), which produces fuel gas, methane and carbon dioxide (biogas); ethanol fermentation, which produces a liquid fuel; and other anaerobic microbiological processes.

Thermochemical conversion denotes technologies that use elevated temperatures to convert the biomass materials by direct combustion to produce heat; pyrolysis to produce gas, pyrolytic liquids, chemicals and char; gasification to produce low or intermediate joule-value gas; and liquefaction to produce heavy fuel oil or, with upgrading, boiling liquid products used as distillates, light fuel oil or gasoline.

In the long term, several possibilities exist for the improvement of biomass as an energy source. These include the genetic manipulation of plants and micro-organisms, the biological production of hydrogen, the use of photochemical cells, new and improved anaerobic energy conversion technology, the fixation of CO_2 and N_2 by means of photochemistry and photobiology, and fuel cells.

In any discussion of new technologies or new resources the question of economics always arises, and cost/benefit ratios are adduced as evidence for or against their adoption. The Panel noted that it is difficult to apply normal economic criteria in many situations, as in cases where political considerations may outweigh economic ones, and that economic criteria may differ from one country to another. Some countries have discounted the potential contribution of small-scale biomethanation on valid economic grounds. On the other hand, others are obtaining significant quantities of energy in rural areas from such systems and consider the effort well worth-while.

Given the inadequacy of economic criteria to evaluate biomass energy sources, the Panel emphasized that each country must decide for itself the wisdom of investment in specific biomass resources and conversion technologies on the basis of its own economic, social, and environmental situations within a specific framework. Any biomass energy system can change the traditional roles of the subsistence farmer and his family and, as a result, as with any change, resistance can be expected. Environmental impacts on biomass energy production are small compared with those of most other energy forms, and may in fact be beneficial if human, agricultural, and industrial wastes are used in the process.

Applicability and Constraints

The Panel noted that agricultural and forest residues, some energy crops, feed-stock preparations, and industrial effluents are immediately available. Others, such as short-rotation forestry, some energy crops, aquatic biomass for biomethanation, and hydrocarbon plants are in the stages of applied research, pilot plants, or demonstration plants, and are projected to be commercially viable after 1990. Similarly, the technologies for direct combustion, gasification, mechanical densification, biomethanation, ethanol fermentation, other anaerobic microbiological processes, and fuels from vegetable oils exist today and could have immediate commercial application. The technologies for pyrolysis, gasification (for medium- and high-joule gas), and cellulosic saccharification will be commercial after 1985, and those for gasification and indirect liquefaction (methanol and synthetic fuels) after 1990.

The Panel identified several constraints common to all biomass energy sources. It was noted that financial constraints could be eased by the introduction of biomass technologies in the budgetary and extra-budgetary programmes of the UN system, and that additional financing might be available from the UN Development Programme, the World Bank, Regional Development Banks and other national and international funding institutions, as well as from commercial sources. The Panel recommended that with respect to the rural sector, attention be given to the savings that might accrue from the non-implementation of an expensive rural electrification system. The Panel also placed special emphasis on the constraints posed by the lack of current education, training, and extension work involving biomass energy. Local training at the engineering, technical, and extension levels is particularly crucial, and could involve workshops and field courses, social science training, general education, and extension, as well as mass media. Other general constraints included the necessity of a conducive political framework, in both industrialized and developing countries; the necessity of information flows, particularly a centralized information base; the current lack of industrial development and engineering input in the biomass field; the inability of some biomass technologies to compete with alternative sources, and finally, the lack of an existing market for biomass energy. Each biomass technology has specific advantages and constraints, each of which was examined in detail by the Panel (for example, although biomethanation is highly efficient, the use of human or pig manure appears socially unacceptable in some regions).

Recommendations

The Panel recommended that the UN, together with other agencies, governments and individuals, establish a global network of biomass energy projects to demonstrate appropriate technologies in realistic situations, and that a biomass energy working group be constituted to assist in planning the demonstration, reviewing the project's progress, and making the results available to all. The Panel stressed the need for immediate international co-operation among research and development institutes and co-operative networks, particularly on small-scale biomethanation, ethanol production, and thermochemical conversion of biomass.

The Panel urged the adoption of national policies that give priority to biomass as a component of overall national energy policies, and that governments consider the specific and potential contributions of biomass energy to national energy supplies in the short, medium, and long terms. In addition, the UN and its agencies should strongly encourage and support national governments in organizing and implementing training programmes for their professional and technical staffs, and extension workers in biomass-energy production, management, and technology.

The Panel especially emphasized the suitability of biomass energy to decentralized production and use in rural areas, urging the participation of both urban and rural communities in the mobilization of resources and the study of biomass-energy production in connexion with other new and renewable sources, as well as establishment of networks of farms and other rural enterprises at regional levels. The UN system should assist developing countries in these efforts.

The UN should encourage and assist governments in setting up national biomass energy centres, should organize an international biomass energy evaluation and implementation office, and should assist in establishing local biomass energy market organizations. The UN should also assist governments in establishing biomass data in selected existing document centres which would collect and distribute information on planning, evaluation, financing and operation of biomass technologies; promote the use of information through conferences and workshops; promote the standardization of equipment and techniques; and co-operate with similar centres in other countries. The Panel stressed that scientific and technical information emerging from these programmes should be made freely available, particularly for the benefit of the rural poor.

Lastly, the Panel recommended that in designing, evaluating, and developing biomass systems, attention be paid to direct and indirect socio-economic costs and benefits which may affect the system's introduction in rural areas and the active involvement of local communities. Systematic consideration should also be given to the impact of biomass systems on such environmental factors as agricultural productivity, livestock grazing, watersheds, soil erosion, and wildlife, particularly as regards their implications for rural life and development prospects.

FUELWOOD AND CHARCOAL

Since the discovery of fire, fuelwood has been the primary renewable source of energy not only for such basic tasks as cooking and heating, but has played a major role in such industrial activities as iron and brick making. Over the past two hundred years, the discovery and efficient use of fossil fuels have boosted industrialization and economic growth in some parts of the world.

The overall energy situation dramatically focuses attention on the crisis faced by 2,000 million people, mostly in the rural areas of developing countries where wood and charcoal together with agricultural residues have remained the predominant if not the only fuel. When these traditional fuels are in short supply, the very basic energy needs for survival are threatened. Already more than 100 million people live in situations where they are unable to obtain sufficient fuelwood to provide minimum energy needs. Roughly a further 1,000 million are affected by lesser but identifiable shortages. By the year 2000, if the present trend continues, over 2,500 million rural people will need other cooking fuels to replace firewood.

To meet the growing demand for wood fuels, deforestation has accelerated excessively. With the removal of tree cover, destruction of fragile arid-land ecosystems (as in the Sahel), and erosion, flooding and siltation (as in the Himalayas) follows. This in turn threatens the agricultural potential and production of food on an alarming scale thereby making this more than an energy issue. It is essential to maintain the stability of the environmental framework on which human life depends.

Based on their own and other studies, the Panel concluded that there is no alternative source of energy that could provide a viable substitute for fuelwood on a scale that would permit a major reduction of the dependency on its use within the next quarter century. The poverty and remoteness of many rural areas diminish the range of possibilities of energy sources. The Panel, however, identified five major action programmes to meet this challenge: intensifying the productivity of existing fuelwood resources; creating new fuelwood resources; organizing the distribution of fuelwood; improving conversion technologies; improved wood-burning stoves; and the use of substitute sources (solar or biogas) as temporary or permanent measures. If developed immediately on the basis of technical and economic feasibility and applied without delay on a sufficient scale, these could result in a substantial improvement of the rural energy situation.

While the only inputs necessary for increased production are land and labour, and while the technologies necessary to increase efficiency are well developed and low cost, there is little awareness at either the public or governmental levels of the tremendous scale of the fuelwood crisis. In light of this, the Panel recommended that the UN Conference on New and Renewable Sources of Energy accept as its most important objective, the creation of awareness of the dimensions and nature of the energy needs that must be met by fuelwood and charcoal, and the stimulation of a public expression by governments and the international community of their determination to implement the actions required in order to meet these needs. The Panel emphasized that effort must start immediately with massive action programmes that will bring about a sizable impact on the rural development potential.

To overcome the institutional, economic and social constraints, the Panel addressed its recommendations to the international community and national governments. It is recommended that national governments adopt policies that clearly demonstrate the high level of political priority and commitment on a scale equal to the urgency of the problem. National forestry policies should give priority to production of fuelwood and to reviewing existing legislation with respect to land tenure, land use, licensing and forestry practices. Governments should substantially intensify training of the required forestry staff and initiate popular education and extension programmes in order to raise awareness and, in particular, involve women in active participation. Applied-research programmes should be encouraged by Governments in the design and development of more efficient systems for the production and use of fuelwood on the basis of a multi-disciplinary approach. Governments should further organize the co-ordination and decentralization of and access to information and experience on current research efforts and programmes.

In all these aspects, the Panel recommended and stressed the role of international organizations in co-operating, stimulating, and facilitating, both technically and financially, the efforts of the governments. With respect to rural infrastructure, action should be taken by governments to identify and solve problems related to the lack of appropriate fuelwood and charcoal distribution systems and to stimulate and strengthen efficient servicing through infrastructure and technical support. In order to maintain the impact of a plan of action, the Panel stressed that a major financial effort is required. The Panel estimated that the financial effort required in order to realize the potential of fuelwood for meeting basic energy requirements by the year 2000 would amount to an average $1,000 million per year over the next 20 years in the developing world.

The Panel recommended that international organizations should promote an international declaration which recognizes energy for cooking and heating as a fundamental human need and stresses the role of fuelwood and charcoal in meeting this basic need in the developing world.

WIND ENERGY

Wind derives its energy from the differential heating of the atmosphere by the sun and the irregularities of the surface of the earth. While only a small proportion of the solar energy reaching the earth is converted into the kinetic energy of the winds, the total quantity is extremely large. Nature concentrates this energy in certain regions, making the average wind energy flux or energy density in many locations equal to or greater than the average energy flux. For example, a site with a 5.5-m per second wind has an average energy flux of about 200 watts per square metre which is approximately equal to the daily average solar flux at a good sunny location.

The wind energy resource is variable both in time and location. Relatively large variations in average wind speed can occur over relatively small geographical distances owing to the effects of terrain and of uneven heating of the earth. This variation is a major advantage as well as a major challenge.

The use of windmills dates from at least the sixth century in Persia with earlier recorded use in China. The oldest known use of wind energy to propel sailing ships can be traced back to the times of the Pharoahs in Egypt. By the nineteenth century, this mode of transport reached its zenith and windmills were in abundance. With the invention of steam engines and rural electrification programmes, both abruptly declined in development and importance.

In the first half of this century, low-solidity wind turbines were developed, operating at a tip-speed ratio of four or more (that is, with blade tip speeds more than four times the wind speed). Though these require good aerofoil section blades, they can achieve efficiencies of 40% or more and are particularly suitable for low-cost electric power generation, where high starting torques are not required.

Since 1973, wind turbines have been the subject of intensive development and the machines now emerging make use of the major technological developments that have taken place in recent years in the fields of structural design, materials and control, taking advantage of an improved understanding of wind loading and rotor-aerodynamic performance.

The Panel, made up of experts from Barbados, Canada, China, Denmark, India, Malta, Syria, the UK and the USA sees major potential from wind energy in the rural areas of developing countries. Even at low average wind speeds, wind-energy systems can play a significant role in pumping water for household needs, animal husbandry, irrigation and drainage as well as integration into large electric-power grids, thereby reducing the consumption of fuel in power stations.

Constraints to wind-energy development can be put into five major categories: infrastructure and institutions; research and development and transfer of technology; education and training; information flows; and finance.

At present, the lack of an institutional framework to develop policies, strategies and programmes in wind energy, the lack of rural infrastructure to promote development of wind for pumping and power generation, and the lack of manufacturing, distribution and maintenance services are the major blocks under the first category.

Even if a decision is made to proceed with the research and development of a wind-energy programme in a country, the successful transfer of technology to the country and its subsequent diffusion is dependent on a number of factors. Although similar, small-scale rural technologies and larger-scale power technologies require different institutional setting. Such factors as access to technical information, equipment, experienced technical advice, research and development facilities to adapt foreign equipment to local conditions, test facilities, performance standards for wind equipment and demonstration facilities suitable for imported or domestic equipment must be considered.

Constraints in the area of education and training include the paucity of advisory and consulting services for decision makers, scarcity of skilled rural extension workers with relevant knowledge as well as the lack of wind-energy specialists and specialists qualified to train others.

The two principal constraints in information flows are the existence of insufficient detailed wind resource data, and the absence of information on wind energy.

Finally, the Panel noted that the financial constraints point to a dearth of funds for financing institutions, technical services and training in developing countries, and the lack of funding for such wind energy projects as water pumps and small- and large-scale power generation. The Panel observed that even when wind energy is cost effective, it is penalized because of the artificially high prices placed on other forms of energy.

The Panel made several recommendations for action to help overcome these constraints. Countries having some prospects for wind energy should designate a national focal point for wind-energy policy making, planning and implementation, and should undertake a preliminary wind-source inventory.

Because of the shortage of wind-energy specialists all over the world, it was recommended that training courses be established on a permanent basis at one or more suitable advanced wind-energy training centres. Active information programmes to provide prompt, accurate, and useful information and related materials on developments, techniques, and experiences to potential users and decision makers should be developed.

The Panel noted that while wind energy conversion systems are capital intensive initially, they become cost effective over a period of time. It is therefore essential to devise suitable financial packages, including low-interest rate loans and subsidies to accelerate the pace of utilization of this energy source.

The Panel took note of the feasibility of using small windmills in large numbers throughout the rural areas of developing countries and stressed the necessity of making definite commitments backed up by adequate infrastructural facilities and financial support. Small-sized and medium-sized wind powered electric-generation systems are expected to be economically viable on a significant scale within the next five years. Many isolated communities, in fact, can take advantage of this technology in the immediate future. The Panel also believed that land-based turbines supplying electric power into grid networks can become commercially viable in 5 to 10 years' time, and by the turn of the century it could be supplied from offshore systems.

Because of the importance of creating national or sub-regional centres for wind-energy technology, international assistance through the United Nations system and other agencies active in the field should be given to countries wishing to establish such centres.

GEOTHERMAL ENERGY

Man's use of geothermal energy goes far back in history. In the earliest times, hot springs were used as baths for near-by populations. Some thermal facilities dating back several thousands of years are still in operation, and in certain regions, the inhabitants cook their food by dipping it directly into springs of boiling water. It was not until the beginning of this century that the first attempts were made to produce electricity from geothermal energy, with the first full-size power station being completed in Italy in 1913. Many of those countries possessing geothermal resources subsequently developed this type of application of geothermal energy, and in 1980 the total installed power capacity from geothermal sources was 2.5 gigawatts (GW), or the equivalent of about fifty thousand barrels of oil a day.

Geothermal energy results from the fact that temperatures in excess of 1000 °C exist deep in the earth, and that the resulting thermal gradient creates a heat flow to the surface. The average value of the thermal gradient is 25 C°/km, the corresponding heat flux averaging 50 to 100 kW(t)/km^2 at the earth's surface. The highest heat flows and thermal gradients are found along fault lines which form the borders of the tectonic plates postulated in the generally accepted theory of continental drift, in areas characterized by considerable seismic and volcanic activity.

At the present stage of technology, wells drilled to tap geothermal sources are limited to 3000 m in depth, but projections of geothermal sources which will be available by the year 2000 include all sources to a depth of 5000 m. Known geothermal resources are estimated to be 14.5×10^{25} joules, or 4×10^{13} GWh(t), the equivalent of about 8×10^{17} barrels of oil.

The Technical Panel on geothermal energy, made up of experts from Algeria, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, the USSR, the USA, and Yugoslavia, examined geothermal energy systems and technologies likely to be significant in the next 10 to 20 years, and studied the constraints on their development and means to overcome these constraints.

The geothermal energy systems which the Panel examined included low-level and high-level temperature hydrothermal systems, hot dry-rock systems, geopressurized zones, and magmas. Low-temperature hydrothermal sources are in extensive use in some areas, such as Iceland where space heating for about 110,000 people is provided from geothermal sources at prices ranging from 15 to 19% of the cost of heating with oil. Other uses of this system include aquaculture, bathing, greenhouse farming, drying of organic products, salt extraction from brine or sea water, and industrial process heat.

High-temperature hydrothermal sources are characterized by high temperatures at relatively shallow depths,and although some problems remain in exploration the Panel noted that the technology to harness this resource is well established for depths to 2000 m. Presently and within the foreseeable future, the main use of high-temperature fields will be for the generation of electricity which the Panel projected would reach an installed capacity of more than 17,644 MW by the year 2000.

Geothermal energy from hot dry rock, while not currently in production, has the potential to produce large amounts of electricity, in some countries at a rate commensurate with current electricity production. The installed capacity of such power stations in the future can be expected to be of the order of 10^5 MW(t). The technology for harnessing this resource, chiefly the fracturing of the rock either hydraulically or by means of subterranean explosions to permit the circulation of a heat-transfer fluid, has been demonstrated to be technologically feasible.

The techniques for utilizing geothermal energy sources include heat exchangers, total-flow turbines, thermogravimetric loops, and binary cycles which recover the waste heat generated by use of other geothermal technologies.

The Panel noted that the principle constraints on the development and use of geothermal energy sources are in the areas of education and training, flow of information, research and development (including applications and transfer of technology), financing, infrastructure, and institutions.

At the international level, the Panel recommended the increased use of existing geothermal training centres by students from a wider range of countries, the establishment of an international documentation centre on geothermal energy, and an international effort to overcome scientific and technical problems as means for accumulating the necessary know-how to exploit geothermal sources. The Panel recommended that a model framework be drafted at the international or regional level to assist countries in composing a geothermal energy code to govern the ownership of geothermal resources, conditions for their use, the charges payable by users, and their fiscal regime.

At the regional level, the Panel's recommendations closely followed those for the international level, with additional proposals included for the establishment of regional training centres, where they do not presently exist, and for the focusing of aid projects in order to encourage the transfer of the technologies necessary for the investigation and development of geothermal resources and the operation and maintenance of the subsequent installation to the fullest extent practicable.

The Panel noted that the main effort must be concentrated on the national level for those countries with geothermal potential because, in the final analysis, it is in that framework that geothermal resources are developed naturally. Moreover, it is at that level that most constraints are encountered. National policies regarding training and education should encourage the fullest participation by their nationals in all available regional and international training schemes, and should encourage the development of national training facilities as rapidly as possible. In addition, institutional measures, such as the development of a geothermal energy code and the designation of a single technical ministry to monitor the geothermal industry, the provision of government assistance for geothermal exploration, and the definition of national resources, should be sought. In order to overcome infrastructure constraints, the Panel recommended the inclusion of geothermal energy in national planning at a very early stage, and noted that priority should be given to the encouragement of geothermal usage on the small scale in order to compensate for the lack of geothermal infrastructure and to maximize the benefits of geothermal energy and the conservation of non-renewable resources.

Finally, the Panel recommended that in order to overcome financial constraints, financing be made available by international financial institutions, and that emphasis be placed on geothermal sources by countries which are now energy importers as a way of improving their balance in foreign trade and that investment incentives from outside the country be planned, and that developing countries ensure the multipurpose use of geothermal resources in order to improve the capacity of repayment of initial capital investment and emphasizes that tax relief measures may in some countries be a prerequisite for a speedy start in the development of geothermal resources. These resources may be developed initially with external technical assistance, but efforts must be made as soon as possible to replace foreign capital goods and services gradually with locally produced equivalents.

OIL SHALE AND TAR SANDS

In the past 150 years oil-shale industries have been established in Australia, China, France, Fed. Rep. of Germany, the U.K., South Africa, Spain, Sweden, and the USSR. In addition, many countries have conducted experimental investigations of energy production from oil shale. The UNCNRSE Technical Panel on oil shale and tar sands, made up of experts from Brazil, Canada, China, Egypt, France, Iran, Morocco, the USA, and the USSR, defined oil shale as a sedimentary rock that contains solid, combustible organic matter, commonly called kerogen which is largely insoluble in petroleum solvents.

Field efforts at energy production from tar have only recently been attempted. Noting that there is no full consensus on the definition of tar sands, the Panel for its purposes defines it as being any material such as unconsolidated sand, sandstone, limestone, or other sedimentary rock, containing oil with a viscosity greater than 10,000 centipoises in its underground conditions. As a result of this character, the in-place oil has a very low mobility, and no significant primary production can be obtained from such deposits. Tar sands differ from other hydrocarbon materials such as oil shales by the fact that the organic matter is essentially soluble in petroleum solvents. They differ from heavy oil reservoirs in the lack of fluidity of the reservoir oil.

World deposits of oil shale are estimated to be 475 billion tonnes, and tar-sand deposits are estimated to be at least one and one half times greater than the conventional crude oil resource base. Not having been actively explored for in the past, oil shale and tar sands became known as a result of general geological investigations or by accident. Thus, it is entirely possible that potentially exploitable deposits may exist in a country. India, for example, has reported no oil-shale deposits, yet it is inconceivable that such a large part of the earth's crust containing such a variety of sedimentary rocks would have no oil-shale deposits. This lack of information on the extent and distribution of oil-shale and tar-sand resources is a major constraint on their exploitation.

The Panel indicated the possibility for oil shale and tar sands to play a significant role in four application areas, namely: large-scale synthetic crude oil production from oil shale; direct combustion of oil shale for electric power generators; small-scale liquid fuel production from oil shale for local consumption; and large-scale synthetic crude oil production from tar sands. Both oil-shale and tar-sand technologies require substantial development and field experimentation to reach production capability, and this limits the significant technologies to those currently in existence or those ready for field testing.

The technologies likely to be significant in the next 10 to 20 years in the production of energy from oil shale include surface retorting, which requires mining of the shale, and in-situ retorting, which involves heating the shale while it is still in the ground and then pumping the oil to the surface. At present, surface retorting technologies are being used at plants in Brazil, China, the USA, the USSR, and the Fed. Rep. of Germany. No commercial in-situ developments exist, and only the USA is conducting in-situ production experiments, with two processes being sufficiently advanced to be significant over the next 20 years. In addition, the USSR has on-going large-scale oil shale operations involving direct combustion to produce electric power, with some plants producing up to 1,600 MW.

As is the case with oil shale, tar sands can either be mined for surface refining (usually strip mined), or treated in-situ to reduce the viscosity of the oil enough to allow it to be pumped to the surface. Most tar sands are located at depths which require in-situ techniques, but to date only surface mining techniques are in commercial operation, notably in Canada where two projects produce a total of 10 million tonnes a year. About fifteen in-situ pilot tests are also in progress in Canada using cyclic steam injections to release the oil, while a thermal in-situ technique is under development in the Orinoco tar-sand deposit in Venezuela. Tar-sand exploitation is constrained by the fact that most known deposits are in remote and sparsely populated areas.

The major constraints on the development of oil shale and tar sands as energy sources for developing countries include a general lack of information and information flows concerning resources, a lack of financing, insufficient research and development, a lack of access to technology, and inadequate education, training, infrastructure, and institutional frameworks.

To overcome these constraints, the Panel arrived at recommendations on the international and national levels.

Emphasizing that international assistance is particularly crucial in the areas of finance and technology, the Panel urged that international financing organizations be made aware of: the favourable prospects for oil shale and tar-sand developments; the urgent need of developing countries for technical assistance in all aspects of development of these resources; the necessity of undertaking oil-shale and tar-sand resource inventory as soon as possible; and the standardization of resource evaluation procedures. The Panel recommended that international arrangements for organizing and financing such assistance be strengthened.

In addition, the Panel drew the attention of Governments to the economic feasibility of small-scale retorting of oil shale for domestic energy in rural areas; the need for the establishment of national oil-shale/tar-sand focal points by countries to assist in policy making, planning, and implementation; creation of national centres for oil shales and tar sands, which could identify existing sources of equipment and services required to establish oil-shale and tar-sand industries, assist in choosing a technology that would best accommodate the infrastructure of a developing country, and identify the institutions that are suitable for educating and training decision makers, managers, professionals, and technicians required to establish and to operate oil-shale and tar-sand industries. These centres could assist in establishing co-operative research and development programmes sponsor seminars that cover resource evaluation procedures as well as tours of on-going commercial ventures, demonstration projects, and research and development facilities. Finally, these centres should accumulate, index, and maintain descriptions of available production technologies.

(Based on summaries prepared by Paul Martin, John Sheehan, James Schlueter, Tanya Chermak and staff of the UNCNRSE Secretariat of the Final Report of the Ad Hoc Technical Panels.)

For further information concerning the UN Conference and its preparations, please contact:
Information Officer, UN Conference on New and Renewable Sources of Energy,
DESI/DPI - Room 1061-J, United Nations, New York, NY 10017, USA. Tel.(212) 754-6875

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in 1-liter conical flasks. CM-cellulase production by the mold was induced by Na CM-cellulose (addition of corn steep liquor showed an inhibitory effect on mold growth). Partial replacement of wheat bran by a penicillin waste (mycelium) did not improve CM-cellulase formation. The addition of C sources such as glucose, soluble starch, and maltose to wheat bran cultures was also investigated. Enzyme extraction remained about the same when water, phosphate buffer, or an NaCl solution was employed.

165/81 APPLICATION OF SGFM TECHNOLOGY TO OTHER FEEDSTOCKS. S.R. Beck (Texas Technical University, Lubbock, TX (USA)). P. 339-47 of Proceedings of the Third Annual Biomass Energy Systems Conference (held Golden, CO, USA, 5 June 1979). SERI/TP-33-285 (Oct. 1979). NTIS.

In 1977 a contract was awarded to Texas Technical University to evaluate non-manure biomass feedstocks in the synthesis gas from manure (SGFM) pilot plant. These feedstocks were to include wood as the major emphasis, along with various agricultural residues which might be available. The agricultural residues which have been or will be looked at are corn stover, cotton-gin trash, sunflower stalks, and sorghum stalks. The SGFM reactor operates as a counter-current fluidized bed in which the solid feedstock is fed to the top of the reactor and fluidized by an upward flowing stream of air, steam, and product gases. This top-feed system provides some advantages over conventional fluidized beds in that the incoming feedstock is partially dried by direct contact with hot product gases. In addition, the initial pyrolysis gases, which are formed quickly, exit the reactor zone and are quenched by the incoming cool solids. As a result, the product gas contains significant amounts of methane, ethane, and ethylene along with hydrogen, carbon monoxide, carbon dioxide, and nitrogen. The major results to date pertain to the gasification of wood. The reactor was operated over the temperature range of 500 to 800 °C. Under these conditions the yields of product gas varied from about 1 m^3/kg to 1.25 m^3/kg. The heating value of the gas was 2700-3600 kcal/m^3. Preliminary results from corn-stover gasification indicate that the gas yields from corn stalks will be very similar to those observed with wood. In both these cases, the gas yields are significantly higher than was seen with manure. An economic evaluation of the SGFM process using wood as the feedstock, indicates that for a 1000 tonne/day plant, a medium-energy fuel gas can be produced for approximately US$3.30 per billion joules, assuming wood chips are delivered to the plant at US$15/tonne.

166/81 ENERGY CROPS: A NEW CHALLENGE FOR TROPICAL REGIONS. P.D.T. Alvim and R. Alvim (Centro de Pesquisas do Cacau, Caixa Postal 7, Itabuna-BA (Brazil)). Renewable Energy Review Journal, vol. 2, no. 2, p. 1-13 (Dec. 1980).

Solar energy captured by plants through photosynthesis is not only the prime source of all of the world's foodstuffs but also is important in the generation of fuels. The main role of agriculture has always been the production of foods and fibres for mankind. In recent years, however, as a consequence of the oil crisis and the depletion of world fossil-fuel resources, plant cultivation aimed at fuel production has been considered as a feasible alternative-energy source, especially in tropical countries where solar energy is abundant. This paper analyses the problem of fuel production from plants on the basis of information drawn from the literature and from case studies conducted in Brazil. Special reference is made to the production of charcoal and the production of alcohol and vegetable oils to replace gasoline and diesel fuel for internal-combustion engines. The potentialities and socio-economic implications of projects based on some efficient energy crops such as sugar cane, cassava, eucalyptus and oil palm are discussed. In addition, attention is called to some plants which are considered promising sources of oil and hydrocarbons but have not yet been fully investigated from the agronomical and/or industrial point of view. 15 refs.

167/81 FUELWOOD AND CHARCOAL IN DEVELOPING COUNTRIES. J.E.M. Arnold (Forestry Department, Food and Agriculture Organization of the United Nations, Rome (Italy)) and J. Jongma. Unasylva, vol. 29, no. 118, p. 2-9 (1977).

This article is an economic survey of the estimated use, energy budget and consumption patterns of fuelwood throughout the developing countries. The use of charcoal is also examined on the basis of available data. It is estimated that the total annual use of all wood for fuel in the developing countries is 1.2 billion m^3. This compares with roughly 150 million m^3 used annually in industrialized countries. 19 refs.

168/81 CHEAP TECHNOLOGY TO PRODUCE CHAR BRIQUETS FROM BIOMASS. H. Johannes (Energy Studies Centre, Gadjah Mada University, Yogyakarta (Indonesia)). Renewable Energy Review Journal, vol. 2, no. 2, p. 33-4 (Dec. 1980).

A simple method to produce char and char briquets (from grasses, weeds, leaves, and agricultural wastes) for domestic and industrial uses is described. This inexpensive technology will provide jobs, earnings, savings of fossil fuels and firewood, and safeguard against deforestation.

169/81 Pithecolobium saman BENTH. (RAIN TREE) FRUITS AS RAW MATERIAL FOR THE PRODUCTION OF ETHANOL. K. Nand, S. Srikanta and V.S. Murthy (Central Food Technological Research Institute, Mysore (India)). Journal of Food Science and Technology, vol. 14, p. 80-3 (1977).

Mature fruits of P. saman Benth. (rain tree) contained approximately 33% sucrose, 4.8% glucose, 0.8% fructose, and 9.6% total protein on a fresh weight basis. The free amino-acid pool of the kernels was particularly rich in an unidentified amino acid which was similar to proline, in some characteristics but distinctly separated from it in the amino acid analyser. It also contained substantial amounts of glutamic acid, serine, and threonine.

170/81 BATCH AND CONTINUOUS PROCESSING OF STARCHY MATERIAL FOR THE PRODUCTION OF ETHANOL (PROCESSAMENTO EM BATELADA E CONTINUO DE MATERIAL OMILACEO PARA E PRODUÇÃO DE ETANOL). G.B. Da Silva. Boletim Tecnico da Petrobrás, vol. 23, no. 1, p. 49-57 (1980).

The parameters governing the principal steps in the production of ethanol from starchy material, particularly from cassava, in both discontinuous and continuous processes are presented. The advantages of heating and continuous hydrolysis followed by batch fermentation are presented. The characteristics of equipment provided by various manufacturers are examined. 18 refs.

171/81 PRODUCTION OF CELLULASE BY A THERMOPHILIC Thielavia terrestris. W.A. Skinner and F. Tokuyama (to Stanford Research Institute). US Patent 4,081,328 (28 Mar. 1978). File date: 8 Sep. 1976. 8p.

A thermostable cellulase preparation exhibiting C_1 and C_x cellulytic activities at a temperature from about 60 to 70 °C and a moderately acid pH (about 5.0 to 5.6) is obtained by culturing the thermophilic fungus Thielavia terrestris (NRRL 8126) in a suitable cellulose-containing medium and recovering the cellulases thus produced.

172/81 SACCHARIFICATION OF CELLULOSE BY ACETOLYSIS. T. Tanaka, S. Yamanaka and K. Takinami (Ajinomoto Co., Inc., Kawasaki (Japan)). Hakko Kogaku Zasshi, vol. 56, no. 4, p. 410-5 (1978).

For saccharification of cellulose, an acetolysis method using assimilable acid with a micro-organism was applied. Based on this method, a new method which gave totally assimilable products, was established. The rigid crystalline structure of cellulose was disrupted by acetolysis with 2 - 2.5 times as much acetic anhydride as cellulose (on a weight basis) and 1 N sulfuric acid as a catalyst. After cleavage of the o-acetyl ester and glycosidic bonds, the resulting amorphous acetolysate of cellulose was easily hydrolyzed by heating it in 1 N sulfuric acid at 120 °C for 1 - 1.5 h without over-disruption of the glucose. 98% of the cellulose used was recovered in the form of hydrolysate having about a 30% saccharide concentration. The hydrolysate obtained was composed of 74% glucose, 13% cellobiose and 11% mono-o-acetyl glucose on a weight basis.

173/81 ALCOHOL PRODUCTION FROM ALGAL STARCH. T. Tatsumi, M. Ohgaki and I. Tanabe (to Muramatsu). Japanese Patent 1977-82,785 (11 July 1977). File date: 1 Dec. 1975. 4p.

Starch-accumulating single-cell algae such as Chlamydomonas and Scenedesmus were cultured in a medium containing C, N, and mineral elements and the starch formed was saccharified and fermented to EtOH. Industrial waste water could be used as a culture media. Thus, S. brasiliensis IAMC-66 was cultured aerobically at 30° for 3 days in a medium containing starch-plant waste water (prg matter 16.8, glucose 13.4, and inorganic matter 0.02 mg/ml) enriched with $NaNO_3$(2.0), $MgSO_4 \cdot 7H_2O$(0.2), $CaCl_2 \cdot 2H_2O$(0.05), $FeSO_4 \cdot 7H_2O$(0.025), K_2HPO_4(0.8), and KH_2PO_4(0.2) g/l. Algal cells were collected, suspended in a small amount of water, and sonicated at 10 kHz for 10 to 20 minutes. The sonicate (10-g dry wt) was suspended in a solution of 2 g H_2SO_4 in 25 ml of water and heated in boiling water for 30 minutes under pressure (2 kg/cm^2) to complete saccharification. The saccharified solution was neutralized and filtered. The filtrate was enriched with $MgSO_4 \cdot 7H_2O$(0.02), K_2HPO_4(0.2), and urea (0.19) g/l and with an alcohol-producing yeast. EtOH was produced.

C2. BIOGAS PRODUCTION AND UTILIZATION

174/81 DESIGN AND ECONOMY OF GOBAR (BIO) GAS PLANT FOR RURAL USE. B.C. Bhattacharyya (Indian Institute of Technology, Kharagpur, West Bengal (India)). Chemical Age India, vol. 30, p. 923-60 (1979).

The design of an anaerobic-digestion plant for agricultural and animal residues is described and an economic analysis of other plants is carried out with consideration given to plant size. 11 refs.

175/81 THE CHINESE DEVELOPMENT OF BIOGAS AND ITS APPLICABILITY TO EAST AFRICA. E.A. van Buren (International Institute for Environment and Development, London (UK)). P. 1-13 of Energy and Environment in East Africa (Proceedings of the International Workshop on Energy and Environment in East Africa, held Nairobi, Kenya, 7-10 May 1979). ERS-3-80 (March 1980). United Nations Environment Programme, Nairobi, Kenya.

During the past 20 years, China has developed a highly successful national biogas programme. The instructions for building, operating and maintaining biogas digesters are contained in a single standard manual which is described. The difference between Chinese and Kenyan conditions and the problems to be encountered in transposing the Chinese experience to Kenya are discussed. The areas most urgently needing further investigation are suggested. 8 refs.

176/81 METHANE DIGESTERS IN REMOTE RURAL AREAS. A. Williams (Monash University, Clayton, Victoria (Australia)). Vol. 3, p. 1273-83 of Alternative Energy Sources (Proceedings of the Alternative Energy Sources Symposium, held Miami Beach, FL, USA, 5 Dec. 1977). T.N. Veziroglu (ed.), Hemisphere Publishing Corp., Washington, DC, USA (1978).

For the rural population of many of the world's industrially developing countries, the energy crisis may be a daily struggle to produce sufficient food and fuel. The shortage of fuel in some countries is so acute that major forests are threatened by the population's necessity to poach wood in order to survive. The use of animal and other wastes to produce a fuel gas in a "methane digester" (biogas converter) can greatly relieve the problem of energy for cooking, but its adoption depends on a system being available within the economic limitations of a rural family. This paper describes some developments of family-size methane digesters and, in particular, some of the problems with installations in the highlands of Indonesia. An ecological system based on biogas conversion is seen to offer substantial advantages in providing fuel, fertilizer for crops, and food for the raising of fish and ducks.

177/81 METHANE FERMENTATION OF THE FODDER YEAST STILLAGE. M.I. Koshel, A.I. Skirstimonskii, L.A. Demchinskaya, M.V. Yatsyuk and B.N. Keller. Мікробіологічний, vol. 39, no. 2, p. 156-9 (Mar. 1977). In Ukrainian.

Utilization dynamics of organic substances present in molasses stillage by fermenting methane-producing bacteria and the end products of this fermentation were studied. The aim of this study was to find ways of enriching the stillage with fodder protein, particularly with B_{12} vitamins, and to establish biological-treatment methods for by-products of the yeast industry. Reducing substances, amino acids, non-volatile carboxylic acids and betaine were utilized most extensively by fermenting bacteria during the first four days of fermentation. Maximum amounts of gases (especially methane, carbon dioxide and hydrogen) were also formed during the same period. During the next fermentation period, more methane and less CO_2 and H_2 were produced. The concentration of B_{12} reached its maximum after 12 to 16 days of fermentation. The stillage fermentation by the methane-producing bacteria and increases in the concentration of B_{12} can be intensified by the adding of different substances containing reducing compounds, amino acids and non-volatile carboxylic acids. 19 refs.

178/81 METHANE PRODUCTION FROM CATTLE WASTE AND DELIGNIFIED STRAW. J.E. Robbins, M.T. Armold and S.L. Lacher (Chemistry Department, Montana State University, Bozeman, MO 59717 (USA)). Infection and Immunity, vol. 38, p. 175-7 (July 1979).

Methane production from added substrate *per se* was found to be approximately twofold greater from delignified straw than that from untreated straw when fermented with cattle manure. 16 refs.

179/81 ENGINEERING FEASIBILITY OF FUELS FROM BIOMASS UTILIZING DAIRY FARM RESIDUE. R.T. Skrinde (Tracy and Brunstrom Co., Seattle, WA (USA)). DSE-2404-T2 (1 July 1978) 37p. NTIS. US$8.50.

The design and operation of a fermentation facility at the Monroe State Dairy Farm, Washington, USA, which produces methane gas from cattle manure are described. The Monroe process is evaluated and the feasibility of adapting the process to energy production on US farms is discussed. Pipe sizes, types of pumps used, and other factors related to operation are evaluated and design changes are recommended. Equipment costs and long-term operating costs are also evaluated.

180/81 A STUDY OF HYDROGEN PRODUCING BACTERIA IN ANAEROBIC DIGESTER (沼气池中产氢细菌的研究). Liú Kèxīn, Xú Jiéguán, Liáo Duōqún, Sūn Guócháo and Shào Tíngjié (Chengdu Institute of Biology, Academia Sinica, Chengdu (China)). Acta Microbiologica Sinica (微生物学报), vol. 20, no. 4, p. 385-8 (1980). In Chinese.

Hydrogen was produced vigorously by adding tuber mill of *Dioscorea zingiberensis* to enrich a culture of biogas sludge. Hydrogen-producing bacteria were able to be enriched in this way and twenty-four strains of hydrogen-producing bacteria were isolated. The amount of hydrogen produced varied with the species of bacteria and the media used. These bacteria were identified as *Enterobacter cloacae*, *Escherichia coli*, *Serratia marcescens*, *Citrobacter freundii*, *Hafina alvei* and *Clostridium acetobutylicum*. *E. cloacae* may be the major component. Its relative number was about 58.3% of the total number of bacteria isolated, and *S. marcescens*, about 16.7% and *C. acetobutylicum*, about 12.5%.

The methane content in the biogas was greatly increased by adding a mixed culture of hydrogen-producing bacteria to an enriched culture of biogas sludge. The carbon dioxide content in it was obviously reduced. 8 refs.

181/81 MEMBRANE-CONTROLLED DIGESTION: EFFECT OF ULTRAFILTRATION ON ANAEROBIC DIGESTION OF GLUCOSE. T.W. Jeffries, D.R. Omstead, R.R. Cardenas and H.P. Gregor (Columbia University, New York, NY (USA)). Biotechnology and Bioengineering Symposium, no. 8, p. 37-49 (1978).

The biological conversion of soluble organic materials to methane by anaerobic digestion is limited by the activity of methanogenic bacteria. This study describes attempts to increase this rate by increasing the supply of appropriate substrates, by removing inhibitory compounds, and increasing the methanogenic biomass by membrane-controlled anaerobic digestion. The objectives were to enhance the rate of methanogenesis by removing acetic and higher organic acids by ultra-filtration as they were formed in an anaerobic digester and to concentrate and recover these acids by water-splitting electrodialysis and membrane-assisted solvent extraction. CH_4 is produced at a high rate from hydrogen and carbon dioxide during fermentation of the organic feedstock to acids. An acetic and methane fermentation, with a standing methanogenic biomass of 10 g/l and a specific activity of 20 mmol CH_4/g-h, would yield about 110 liters of CH_4 and 580 g of acetic acid per liter of reactor volume per day from 780 g of cellulose per liter per day.

D. WIND ENERGY

182/81 CHINA TAPS THE WIND TO PROVIDE POWER IN REMOTE AREAS. Ji Bian. Electrical Review International, vol. 205, no. 17, p. 51 (2 Nov. 1979).

An 18-kW wind-turbine generator has been operating successfully for one year on Sijiao Island and is the prototype for a standardized range of medium-size wind-driven generators to meet the needs for electricity in remote areas. It starts generating electricity when the wind velocity reaches 4 m/s and it operates at full capacity when the velocity reaches 8 m/s. The turbine rotor blades are 13 m in diameter and the supporting tower is 12.9 m high.

183/81 WIND MILLS FOR RURAL INDIA. K.L. Kumar (Indian Institute of Technology, New Delhi (India)), O.P. Grover and R.C. Sachdeva. Vol. 3, p. 1838-42 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

Studies of different types of windmills reveal the possibility of adapting some of them for rural India. A vertical-axis vertical-blade windmill (a version developed by the first author) is seen to be suitable for providing a self-sufficient rural utility system for Indian conditions. A horizontal-axis multi-blade rotor (designed by the other authors) is found to be operational at low wind speeds and useful for high initial-torque tasks such as sugar and oil extractors. 5 refs.

184/81 A FOUR-BLADED CSC WINDPUMP FROM MALAWI. Christian Service Committee of the Churches in Malawi (P.O. Box 949, Blantyre (Malawi)). Appropriate Technology, vol. 6, no. 1, p. 23-4 (1979).

This article describes construction and operation details of a simple wind pump. The wind pump operates at wind speeds from 1 - 8 m/s. Plans for its improvement are included.

185/81 AN OSCILLATORY WIND ENERGY CONVERTOR. G. Ahmadi (Department of Mechanical Engineering, University of Shiraz, Shiraz (Iran)). Wind Energy, vol. 3, p. 207-15 (1979).

This article begins with an examination of the non-linear theory of wind-energy conversion using the oscillations of an aerodynamically unstable system. The results of experimental studies carried out on a small model are reported. 18 refs.

186/81 VARIABLE-STROKE, WIND-OPERATED WATER-PUMPING SYSTEM. T. Vinayagalingam and S. Sivasegaram. Wind Engineering, vol. 3, no. 2, p. 127-31 (1979).

The variation of the stroke of a reciprocating water pump is one method of varying the pump-load torque. Variable-displacement designs exist for nearly every known positive-displacement type of pump. These designs, however, cannot be directly adopted for the present purpose and, in any event, none of them can be considered as simple in construction. This article presents the design of a stroke-adjusting mechanism for reciprocating water pumps driven by a wind rotor. The design is simple and is essentially a closed-loop type of control device which ensures that the rotor operates at its optimum speed at any given wind speed.

187/81 PERFORMANCE MATCHING AND OPTIMIZATION OF WIND POWERED WATER PUMPING SYSTEMS. G.M. Bragg and W.L. Schmidt (Department of Mechanical Engineering, University of Waterloo, Waterloo, N2L 3G1 Ontario (Canada)). Energy Conversion, vol. 19, p. 33-9 (1979).

A method of optimizing the choice of pumps and wind machines for pumping water under given conditions are presented. 7 refs.

188/81 COST-EFFECTIVENESS OF THE VORTEX-AUGMENTED WIND TURBINE. O. Igra (Ben-Gurion University of the Negev, Beersheva (Israel)). Energy, vol. 4, no. 1, p. 119-30 (Feb. 1979).

Cost estimates for the conventional horizontal-axis and vortex-augmented wind turbines are presented. For the latter, the vortex is generated by an appropriate delta wing. It is shown that the vortex-augmented wind turbine competes well with the conventional type. Its economical advantage increases with increasing output power. 21 refs.

E. ENERGY STORAGE

189/81 FUNDAMENTAL STUDIES ON HEAT STORAGE OF SOLAR ENERGY. T. Tanaka, T. Tani, S. Sawata, K. Sakuta and T. Horigome (Electrotechnical Laboratory, Tokyo (Japan)). Solar Energy, vol. 19, p. 415-9 (1977).

A study of sensible-heat storage is reported. In this case, temperature distribution in the heat-storage medium is important from the viewpoint of storage-reservoir design and quantity of heat used for the generation of electrical power and the application of the lower grade thermal energy to space heating and cooling. The fundamental study is made on the effect of size and thermophysical properties of a storage material on the rate of temperature increase and quantity of heat stored in the material. These effects are considered as a problem of unsteady heat conduction in a hollow cylinder and a composite hollow cylinder at the centres of which constant heat flux is supplied. These models make clear the thermal characteristics of storage material and the performance of storage-type flat-plate collectors.

190/81 PERFORMANCE STUDIES OF A FINNED HEAT PIPE LATENT THERMAL ENERGY STORAGE SYSTEM. A. Abhat (University of Stuttgart, Stuttgart (Fed. Rep. of Germany)). Vol. 1, p. 541-6 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

Performance studies of a modular heat-pipe heat-exchanger concept for use in a latent thermal energy-storage system for solar heating applications were undertaken. A thermal analysis determined the influence of various geometric and thermal parameters on the storage charging time and temperature gradients for heat flow into two very different storage substances. Additionally, experiments were performed with a small 6-l test model filled with a paraffin. Results indicate the capability of the heat exchanger concept to operate within small temperature swings (< 10 K°) for realistic heat input rates. Comparisons between data and prediction for the test model show adequate agreement. 8 refs.

191/81 STORING SOLAR BTU: NEW TECHNOLOGIES SHOW PROMISE BUT COST-EFFECTIVENESS IS THE KEY. J. Lawn. Air Conditioning and Refrigeration Business, vol. 35, no. 13, p. 37-9 (Nov. 1978).

Phase-change materials are reviewed in regard to their application to latent-heat storage of solar energy. While water and rocks are suitable for thermal storage, they require costly insulated containers and large storage spaces. Salt-hydrates are considered low-cost phase-change materials. Sodium sulfate decahydrate (Glauber's salt) has a heat-storage capacity of about 360 joules/cm^3 but has a lower melting point than may be optimum for a heat source and has problems of incongruent melting. Sodium thiosulfate has a higher melting point (40 °C) but has supercooling problems. Methods for reducing crystal precipitation in Glauber's salt include the utilization of additives (which suspend the salt and create a closed-cell honeycomb structure). Several applications of phase-change materials for potential marketing include: the development of a system which stores latent heat in three temperature ranges; eutectic salts in conjunction with an immiscible heat-transfer fluid; and a two-tank unit incorporating 380 liters of sodium hydroxide and 190 liters of water.

192/81 DESIGN AIDS FOR PARTICULATE BED SYSTEMS FOR SUMMER COOLING. P. Chandra and R.S. Pal (Centre for Building Research Institute, Roorkee (India)). Research Ind., vol. 23, no. 3, p. 135-42 (Sept. 1978).

A design procedure for optimizing various parameters concerning the use of the rock-bed thermal-storage system for cooling buildings is described. The parameters that can be determined include the cooling load of the proposed buildings, outdoor climate data, heat-pickup air-circulation rate, pile volume, air velocity, bed dimensions, heat-transfer coefficient, pressure drop in the pile, and pile and air temperatures. The results of a study on optimization of rock size are presented. The curves developed can be used to determine power consumption for driving the air through the rock beds.

193/81 AN INVESTIGATION OF THE THERMAL ENERGY STORAGE CAPACITY OF GLAUBER'S SALT WITH RESPECT TO THERMAL CYCLING. S. Marks (Institute of

Energy Conversion, University of Delaware, Wilmington, DE 19808 (USA)). Solar Energy, vol. 25, p. 255-8 (1980).

Calorimetric measurements have been performed on mixtures of Glauber's salt and borax and Glauber's salt, borax and attapulgite clay (the last serves as a thickener) in order to compare the thermal energy-storage capacity of the unthickened mixture to the thickened as a function of thermal cycling. The results show a significant improvement in performance of the thickened mixture over that of the Glauber's salt and borax mixture. However, the thickened mixture shows a decline in performance with thermal cycling, several hypotheses to rationalize the decline are presented, tested and discussed. 22 refs.

194/81 MACRO-ENCAPSULATION OF HEAT STORAGE PHASE-CHANGE MATERIALS FOR USE IN RESIDENTIAL BUILDINGS. FINAL REPORT, SEPTEMBER 29, 1976-SEPTEMBER 6, 1978. G.A. Lane, A.C. Kott, G.L. Warner, P.B. Hartwick and H.E. Rossow (Dow Chemical Co., Midland, MI (USA)). ORO-5217-8 (Nov. 1978) 168p. NTIS. US$13.50.

Objectives are to assess the feasibility of macro-encapsulated PCMs for residential solar energy systems and to develop and evaluate such materials. Encapsulant materials under consideration are multi-layer flexible plastic films, steel cans, and plastic bottles. Storage studies were done on: $CaCl_2 \cdot 6H_2O$ encapsulated in polyethylene bottles; $Mg(NO_3)_2 6H_2O$ in steel cans; $Mg(NO_3)_2 6H_2O/NH_4NO_3$ eutectic encapsulated in flexible plastic film packages; NH_4Br/urea eutectic in polypropylene bottles; and a combined bed of $CaCl_2 \cdot 6H_2O$ and $Mg(NO_3)_2 6H_2O/NH_4NO_3$ eutectic. In most cases, charge and discharge capacities in excess of 90% of theory were obtained. Several designs using encapsulated PCM were analysed, one was selected, and preliminary designs were developed for a demonstration project.

F. SOCIO-ECONOMIC ASPECTS

195/81 AN EVALUATION OF THE STRATEGY OF LOW-COST HORIZONTAL-AXIS WINDMILLS. S.K. Tewari (National Aeronautical Laboratory, Bangalore (India)). Vol. 3, p. 1848-53 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

An attempt is made to assess the relative cost effectiveness of three windmill designs with efficiencies greater than 5%. Two of the versions are low-cost technology windmills constructed from locally available materials. The third is an all-metal factory-produced windmill. The economics of these windmills are discussed. 5 refs.

196/81 PHOTOVOLTAICS AND ENVIRONMENTAL IMPACT CONSIDERATIONS. E.R. Weber (Arizona Public Service Co., Phoenix, AZ (USA)). P. 1.224-1.254 of Proceedings of the US Department of Energy Photovoltaics Technology Development and Applications Program Review Conference (held Arlington, VA, USA, 7 Nov. 1978). 1978.

An overview is given of the proposed Airport Solar Photovoltaic Concentrator Project (ASPCP). The scope of the evaluation follows the Council on Environmental Quality Guidelines on Preparation of Environmental Impact Statements. Problems of electromagnetic interference, eye hazard and distractive glint were evaluated. To analyse the environment affected and the potential environmental impacts to both the site and potential facility, the factors of geology, soils, biology, archaeology, land use, zoning, waste disposal, air, radio-service interference and eye hazards were evaluated. Conclusions and recommended actions are presented that pertain to the initiation of construction of the proposed 500 kW peak-capacity solar photovoltaic-concentrator system.

197/81 ECOLOGICAL CONSIDERATIONS OF THE SOLAR ALTERNATIVE. M. Davidson, D. Grether and K. Wilcox (University of California, Berkeley, CA (USA)). LBL-5927 (Feb. 1977). Lawrence Berkeley Laboratory, University of California, Berkeley, CA, USA.

The main solar technologies which are considered include solar-thermal power, photovoltaic cells, ocean-thermal power, wind energy, solar heating and cooling, bioconversion, and agricultural and process heat. The direct and indirect ecological and environmental impacts of these technologies are discussed.

198/81 CURRENT COSTS OF SOLAR POWERED ORGANIC RANKINE CYCLE ENGINES. E. Barber (Barber-Nichols Engineering Co., 6325 W. 55th Ave., Arvada, CO 80002 (USA)). Solar Energy, vol. 20, p. 1-6. (1978).

Solar energy can be used to heat and cool buildings, drive irrigation pumps, produce electrical power, desalt sea water, and, in general, reduce energy demands on conventional energy sources. The organic Rankine-cycle engine will play an important part in the conversion of solar energy to useful shaft power. Technical feasibility is here now, as shown by several demonstration projects; however, economic feasibility may be some years away. This paper addresses the technical and cost aspects of the organic Rankine cycle and its interaction with the solar collector as a power system. 8 refs.

La energía solar puede utilizarse para calentar y enfriar edificios, accionar bombas de riego, producir energía, desalinizar agua de mar y en general, reducir la demanda sobre las fuentes tradicionales de energía. El motor de ciclo Rankine orgánico cumplirá un papel importante en la conversión de la energía solar en mecánica. Técnicamente es viable en la actualidad, como lo indican varios proyectos demostrativos, sin embargo, su factibilidad económica recién se logrará dentro de algunos años. Este artículo se refiere a aspectos técnicos y de costos del ciclo Rankine orgánico y su interacción con el colector solar como sistema energético. 8 réf.

L'énergie solaire peut être utilisée pour chauffer et refroidir des habitations, entraîner des pompes d'irrigation, fabriquer du courant électrique, dessaler l'eau de mer, et, en général, réduire la demande d'énergie de type classique. La machine à cycles de Rankine organique jouera un rôle important dans la conversion de l'énergie solaire en énergie utilisable. Sa practibilité technique est maintenant certaine, comme l'ont prouvé plusieurs projets de démonstration. Toutefois, du point de vue économique, sans doute celle-ci ne fera-t-elle ses preuves que dans quelques années. Cet article reprend les aspects techniques et économiques du cycle de Rankine organique, et son interaction avec les capteurs solaires dans un système de production d'énergie. 8 réf.

199/81 ECONOMICS OF SMALL SOLAR POWER PLANTS. B.S. Jagadish (Indian Institute of Technology, Bombay (India)). P. 180-5 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

Solar power plants with outputs in the range of 5 to 25 kW are of considerable interest for rural applications in India. Economic aspects of thermo-mechanical conversion using a flat-plate collector system are considered. Both the capital cost and the cost of energy per kWh are determined and some broad conclusions are drawn.

SELECTED ARTICLE

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THE XINBU SYSTEM:

AN INTEGRATED RURAL PRODUCTION SYSTEM

by

Mài Xīnshèng, Third Production Team of the Xinbu Brigade, Leliu People's Commune, China;
Chén Rǔchen and Lǐ Niàn-guó, Guangzhou Institute of Energy Conversion, China;
Hú Chéngchùn, State Scientific and Technological Commission, Chinese Government; and
Walter Shearer, Natural Resources Programme, United Nations University, Tokyo, Japan.

It has always been the dream of scientists and development planners to create the self-sufficient rural society producing virtually all its material needs and enough extra to sell or barter for the remaining essential supplies that must come from outside. In China such integrated rural production systems have got nearer to self-sufficiency than anywhere else. Here is the story of one of them.

Located at the confluence of the North and West Rivers of the Pearl River Delta, in Guangdong Province of China, is the Leliu People's Commune. The more than 90,000 inhabitants of this commune are divided into 29 production brigades. In one of these, the Xinbu Brigade, the Third Production Team has integrated a mixture of traditional and modern technologies into a complex system for generating agricultural produce and at the same time satisfying most of the local needs for food, energy and fertilizer.

Many systems for recycling wastes and integrating several agricultural, aquacultural and renewable energy components have been conceived and a few are operational. However, the Xinbu system is, apparently, the only one which is actually a living evolving system supporting the lives and livelihood of as many as 89 families. It is of particular interest to note that this system is considerably more complex than the systems so far planned, indicating that under actual rural conditions the potential for interconnecting biological and renewable energy components into a harmoniously functioning system is perhaps greater than generally realized. This sytem includes both traditionally evolved components and improvements introduced with the assistance provided by specialists from the Guangzhou Institute of Energy Conversion of the Chinese Academy of Sciences. The system is presently undergoing further development with the introduction of improved digesters and solar water heating installations.

The United Nations University's Natural Resources Programme is undertaking socio-economic and ecological studies of a similar system in Shunde County which does not include the alternative sources of energy of the system reported here.

Operation

Once the system in its present form is in operation it requires the importation of some foods, night soil, grass and some of its electrical energy as well as chemical fertilizers, although to a decreasing extent.

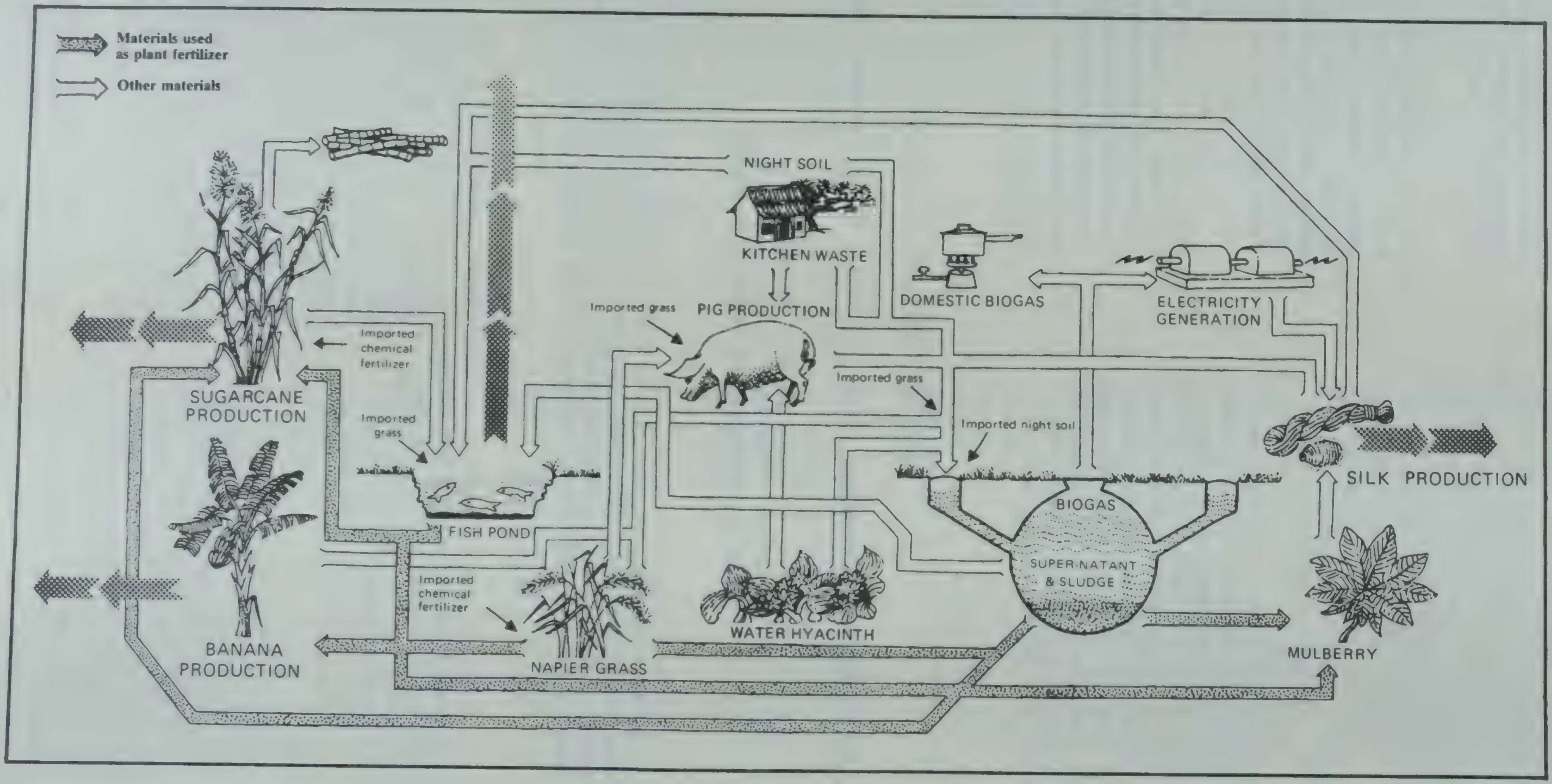
The community produces sugarcane, silk, fish, pigs, bananas and semi-processed fruits which more than cover the purchase of or energy expended in obtaining the imported items. In addition the community produces for its own consumption vegetables, pork, fruits, fish and biogas.

The system is operated so as to optimize the continuous use of available materials, thereby reducing inefficiency due to bottlenecks and slack in the system. The general layout of the components of the system is designed to minimize energy use for transportation.

Improved system

This system is actually an improvement of the traditional village agricultural system practised in the area which includes fish ponds, pig raising, sugarcane cultivation, mulberry cultivation and silk production with some recycling of waste products. The introduction of Napier grass plantations and biogas digesters for energy and fertilizer production have markedly improved agricultural production but also set more rigid requirements on the matching of the various components of the system. The resulting increase in living standard has been accompanied by a significant improvement in sanitary conditions.

The electricity generated by the biogas-powered generator now covers 40 per cent of the production team's electricity consumption, the remainder of which is supplied by the local power grid. In addition, biogas utilization has largely replaced the dependence on wood for cooking and coal for drying. Similarly the sludge from the digesters has reduced the previous dependence on chemical fertilizers.


Materials used as plant fertilizer
Other materials
NIGHT SOIL
KITCHEN WASTE
PIG PRODUCTION
Imported grass
DOMESTIC BIOGAS
ELECTRICITY GENERATION
Imported chemical fertilizer
SUGARCANE PRODUCTION
Imported grass
Imported grass
Imported night soil
SILK PRODUCTION
BIOGAS
FISH POND
SUPER-NATANT & SLUDGE
Imported chemical fertilizer
WATER HYACINTH
BANANA PRODUCTION
NAPIER GRASS
MULBERRY

Sugarcane

One of the exports, 135 tonnes of sugarcane is produced annually per hectare. The waste from processed sugarcane is recycled with the leaves being consumed by the grass carp and the sun-dried stem waste being burned for cooking or used as fibre. Biogas-digester and fish pond sludge is supplemented by some chemical fertilizer. 4.3 hectares are planted with sugarcane.

Bananas

Another export, bananas are also produced on about one hectare. Most of the banana waste generated is fed to the biogas digesters.

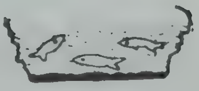
Napier grass

This grass is an energy crop grown for biogas generation and is added to the digesters either in raw form or after mastication by pigs. Biogas-digester and fish pond sludge are supplemented by some chemical fertilizers for Napier grass fertilization. Annual productivity is about 313 tonnes per hectare.

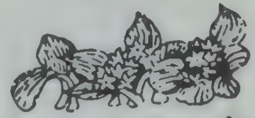
Pigs

Raised for export and local consumption, pigs consume mainly water hyacinth leaves, imported grasses and kitchen waste. Their waste is a valuable component for biogas-digester operation. The Napier grass which they chew is regurgitated and added to the biogas-digester input. This pretreatment is both biological and mechanical.

Fish ponds

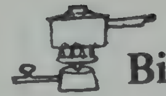


Four species of fish are produced for export, each occupying a special ecological niche in ponds which cover 18 hectares. The grass carp *(Ctenopharyngodon idellus)* occupying the middle layers of the pond consume water plants, sugarcane leaves and local and imported grass, while the silver carp *(Hypophthalmichthys moritrix)* of the middle layers and the bighead or variegated carp *(Aristichys nobilis)* of the upper and middle layers feed on plankton and algae which grow on the waste deposited in the pond. The dace *(Cirrhina molitorella)* of the lower layers consume the scum at the bottom of the pond. Each hectare of fish pond produces 4,450 kg of fish per year on average. The sludge at the bottom of the fish pond serves as fertilizer for sugarcane, bananas, mulberry and Napier grass cultivation. With fish ponds distributed throughout the commune, they serve as a convenient recipient for public waste from villagers away from home.



Water hyacinth

This aquatic weed is harvested from nearby rivers and fed to pigs which consume the leaves. The bulbs are added to the biogas-digester input. Annual productivity is about 1,050 tonnes per hectare of water surface.



Biogas

Eighty-four family biogas digesters have been installed for nearly every family and 7 other digesters with a total volume of 235 m³ are operated on a communal basis with biogas storage in two 45m³ balloons. The family digesters operate mainly on night soil from the family and the waste of its pigs supplemented by Napier grass, banana waste, water hyacinth bulbs and kitchen waste, whereas the communal digesters also consume silkworm waste and imported night soil. The biogas generated by family digesters is burned for cooking and lighting. The biogas from the communal digesters powers a motor to drive a 12 kW electric power generator at the rate of 1.5 kWh per m³ of biogas. The electric power is used to operate electric lights and a pulveriser. The waste heat from the motor is channeled into the silkworm cocoon drying shed. The supernatant from the digesters is added to the fish ponds to serve as nutrient for algae growth while the sludge is utilized on a variety of fields throughout the village. The village digesters consume daily two tonnes of waste material. A family biogas digester of about 1 m³ requires about two man-days to construct from materials (cement, bricks, sand, lime and water) and costs about RMB 14.8 Yuan. The digesters operate year round except for cleaning periods totalling about three days per year.

Mulberry and silk

Mulberry bushes are cultivated on the slopes of the dikes surrounding the fish ponds and cover about 6.3 hectares. At an annual productivity rate of 60 tonnes per hectare, the mulberry leaves are fed to silkworms which are kept warm during the cold season by biogas heaters. Silkworm droppings are fed to fish (about 25 per cent) as well as to the biogas digesters (75 per cent). The silkworm cocoons are dried using waste heat from the biogas motor which produces higher quality silk much more quickly than the traditional method of drying using coal-generated heat.

FUTURE DEVELOPMENT

The Chinese Government, recognizing that the best way to meet the energy demands of rural communities is to make use of locally available energy sources, began early this year to support the development of the production team as a demonstration new energy village. Based mainly on the existing biogas programme, supplemented by other biomass and solar energy components, the targets are to supply every family in the village with 70-80% of their total energy needs from these sources and to establish community biogas digesters and a biogas power station to generate electricity for domestic uses and processing agricultural products. In addition to the system described below, improvements and additional components are being tested.

One important improvement is the floating-cover type biogas digester. This model which is seen to hold great promise consists of a cylindrical pit and a gas-holding cover made of a bamboo frame covered with asphalt and a plastic sheet. In addition to being easier to construct, clean and operate, a major advantage is the 20-25% improvement in productivity of this model over the common dome-type Chinese digester. This increase in productivity is the result of the possibility of increasing the sludge concentration by 10% without risk of clogging the digester. The cost of the components used in making the cover is about RMB 5 Yuan. Sixty such digesters are planned for the village and will largely supplement the existing biogas digesters.

The newest components being tested for introduction into the system are solar water heaters of the simple pond type which are built directly on to the roofs of the residences. Made of cement, sand, black paint and glass and measuring 0.72 m^2, these devices can preheat 30 liters of water to 50-60 °C in summer and save 45-50% of the biogas required for domestic water heating on an annual basis.

The impact of using a comprehensive biogas-solar energy system can be understood from tests indicating that a 5.5 m^3 biogas digester and a 0.72 m^2 pond-type solar water heater can supply 90% of the energy previously provided by firewood for a family of four.

ANNEX

The Guangzhou Institute of Energy Conversion is undertaking other research projects in the field of bioconversion technology which may be of interest to other readers. Below is a short description of two such projects with some of the results obtained thus far.

PARTLY FILLED ANAEROBIC FILTER

In 1966, an anaerobic filter, which is suitable to treat dilute soluble organic waste water, was invented. Its outstanding advantages were a high reaction rate and a short retention time, thus, allowing volume to be minimized and costs saved. After the operation for several months of a Chinese filter in 1978 clogging occurred and the feedstock was diverted through a bypass with a very short retention time. As a result, the treatment efficiency decreased and the COD removal dropped to as low as 60%.

A partly filled anaerobic filter was developed to improve treatment efficiency. Only two thin layers of stone were set into the filter to maintain a porosity of 91.1%. The operation parameters were as follows:

Filter Volume (including stones)	31 ℓ
Temperature	28 °C
Influent Concentration	9000-g COD/ℓ
Loading Rate	7.26-g COD/ℓ-day
Gas Production	542 cc/g COD added
Gas Production Rate	3.94 v./v.d
CH_4 Content	61%
Liquid Retention Time	1.13 day
COD Removal	83.8%

A considerable amount of alkali was needed to neutralize acidic feedstock (such as alcohol distillate, pH of 3-4) which increased operational costs. A "complete-mixing" filter was developed in which the influent was mixed with the effluent at a specific ratio (pH of mixture of about 7). The system was operated at a loading rate of 3-g COD/ℓ-d for 50 days. It appeared to be stable and easy to control with no risk of acidification. The loading rate will soon be increased to 6-g COD/ℓ-d. Many pilot plants are being planned and research is continuing to develop an even better system.

GASIFICATION OF BIOMASS

In China, many residues (agricultural, forestry, industrial, etc.) are not fully utilized. For example, forestry and wood-processing residues are 37% of the total wood production. The average utilization rate of these residues is only 10%. If 60% could be gasified and then utilized to generate electricity, it would be equivalent to 10% of the total energy consumption in China. It is evident that the utilization of renewable biomass residues to produce fuel gas is important and has great potential. In the gasification process, solid carbon and gaseous O_2, H_2O and CO_2 are involved. Stress is placed on the reduction reactions between C and H_2O as well as C and CO_2. High temperature and low pressure are important in reduction processes, and with the oxidation of carbon by O_2 supplying the necessary heat of reaction, raising heat-transfer efficiency and decreasing heat losses are important factors for speeding up reactions. Using small particles and a fast gas flow in a gasifier increases the heat and mass-transfer rate and, thus, the reaction rate. The fluidized bed utilizes both of these parameters and has a contact area between solid and gas of about 3280-49200 m^2 per m^3 of bed volume so that the production rate is much higher than that for a fixed bed.

A small-scale fluidized-bed gasifier has been designed with a diameter of 50 mm and a total height of 1000 mm. When gasification is carried out at 1 atmosphere and 750 °C, 1 kg of wood (wet) consumes about 1 m^3 of air and produces about 2 m^3 of fuel gas with an average heat value of 1700 kcal per m^3. The composition of gas is as follows: CO_2(15%), CO(15%), H_2(15%), N_2(40%), CH_4 and unsaturated hydrocarbons (5%), and H_2O(10%).

There are many future plans for the optimization of all parameters involved in the gasification process as well as the construction of various pilot plants and the development of new processes of gasification.

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

6 18 87

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811   Telex: J 25442
Cable: UNATUNIV TOKYO

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Abstracts of Selected Solar Energy Technology

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OFFICIAL NEWSLETTER OF THE UNITED NATIONS CONFERENCE ON NEW AND RENEWABLE SOURCES OF ENERGY

THE UNITED NATIONS UNIVERSITY

UNITED NATIONS CONFERENCE ON
NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

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THE UNITED NATIONS UNIVERSITY
Printed in Japan 1981

INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy

  B1 Radiation Measurement
  B2 Photovoltaic Conversion
  B3 Active Thermal Systems
  B4 Passive Thermal Systems

C. Bioconversion Energy

  C1 Biomass Production and Conversion
  C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

200/81 SELF-RELIANT DEVELOPMENT - AN IFIAS SPONSORED STUDY. C.V. Seshadri, R.N. Roy, V. Geethaguru, N.J. Bai, N. Kershavraj, R. Manoharan, G. Raia, V. Subramani, S. Thomas, G. Venkataramani (Shri AMM Murugappa Chettiar Research Centre, Madras (India)), M. Slesser, C. W. Lewis and I. Hounam. International Federation of Institutes of Advanced Study, Stockholm, Sweden (Mar. 1981).

The concept of enhancing the self-reliant development of Third-World rural communities via the implementation of appropriate bioconversion and solar technologies is examined in this study. A community that increases its indigenous energy and food production becomes less subject to the vagaries of external influences over which it has little or no control. This study attempts to determine under what conditions such self-reliance can be achieved and what are the impediments, dynamics of change and side effects of this process. A systems-simulation technique was used to monitor through time the probable effects of various combinations of generally low-cost technologies introduced into the village of Injambakkam in south-eastern India. The relevant data concerning this village were collected by members of the Shri AMM Murugappa Chettiar Research Centre. Under the conditions simulated, the integrated installation of biogas plants, algal ponds, legume-producing farms, energy tree plantations and water-pumping windmills (together with improved agricultural practices) can result in annual per capita increases of calorie intake, protein consumption and indigenous energy production of 245, 140 and 90%, respectively. Moreover, the overall solar energy captured within the village boundary increases by 155% and the community moves from a net importer to an exporter of fuel. All this can occur within 12 years, assuming a stable population, with the added bonus of a healthy annual balance of payments surplus brought about by increased output coupled to import reductions. The under-employment problem currently existing in Injambakkam can be greatly eased, while much of the drudgery and inconvenience associated with firewood gathering, poor or non-existent lighting and cooking over a smokey stove are essentially removed. All of this leads to a marked improvement of the villagers' standard of living which might even help reduce the present undesirable mass migration to the cities. The report concludes that while much work still needs to be done in this area, including the continued development of decentralized low-cost technology and the convincing of policy makers in India and throughout the Third World, there does indeed exist potential for an increased use of solar energy through biotechnologies as an aid to rural development.

201/81 WIND AND SOLAR-POWERED REVERSE OSMOSIS DESALINATION UNITS - DESCRIPTION OF TWO DEMONSTRATION PROJECTS. G. Petersen, S. Fries, J. Mohn and A Müller (Gesellschaft für Kernenergieverwert in Schiffbau und Schiffahrt, Gösthact-Tesperhude (Fed. Rep. of Germany)). Desalination, vol. 31, p. 501-9 (1979).

Two demonstration projects are under study in the Fed. Rep. of Germany in co-operation with plants in Mexico which use wind and solar energy to power reverse-osmosis desalination units. The main objective of these projects is the operation of two prototype plants to demonstrate their reliability and low-maintenance requirements when they are located in remote areas with poor infrastructure. The engineering design, the site conditions and the provided operation mode of two reverse-osmosis desalination plants with a German plate-module system supplied by a 6-kW wind-energy converter and a 2.5-kW solar generator, respectively, are described. 21 refs.

202/81 YOUR SOLAR ENERGY HOME, INCLUDING WIND AND METHANE APPLICATIONS. D. Howell. Pergamon Press, Oxford, UK (1979) 237p.

This book covers: solar energy in the USA, UK, Europe, Australia, New Zealand, South Africa, and Canada; how to collect and store solar energy; combined-collector stores; how to use solar energy; producing a solar collector; 5 schemes for solar-heated domestic water; 4 schemes for solar heating; a backyard solar furnace; wind and water-power schemes; production and use of methane gas; the economics of solar energy; and future developments of solar energy.

203/81 SOLAR ENERGY DISTILLATION OF ALCOHOL (DISTILLATION DE L'ALCOOL A PARTIR DE L'ENERGIE SOLAIRE). M. Guillemot, R. Lebourg and J. Fontaine (Centre d'Etudes Nucléaires de Saclay, Commissariat à l'Energie Atomique, Gif-sur-Yvette (France)). DGRST-77 7 1222. Délégation Générale à la Recherche Scientifique et Technique, Paris, France (1980) 40p.

The design, construction and testing of a distillation column heated by concentrating solar collectors are presented. 3 refs.

La conception, la réalisation et l'essai d'une colonne à distiller chauffée par des collectors solaires à concentration sont présentés. 3 ref.

204/81 PHOTOCHEMICAL CONVERSION AND STORAGE OF SOLAR ENERGY. J.R. Bolton (University of Western Ontario, London (Canada)) and D.O. Hall. Annual Review of Energy, vol. 4, p. 353-401 (1979). Annual Reviews, Palo Alto, CA, USA.

The general principles and limitations of converting solar energy via photo-chemical reactions to electrical or chemical energy are described. Photosynthesis is found to be the only reliable and efficient system, suggesting that research efforts should aim at mimicking the photosynthesis process and modifying it to produce other fuel sources, such as hydrogen or ammonia, or developing artificial photochemical systems. Few economic studies are available because the field is still too new and few systems show a reasonable degree of efficiency or longevity. Early work indicates that a simple hybrid system able to operate as a single unit may have the most economic feasibility. Economic assessment, however, should wait until scientific feasibility is established. 190 refs.

B. SOLAR ENERGY

205/81 SOLAR ENERGY RESEARCH AND APPLICATION IN CHINA. L. Ti. Helios, no. 7, p. 3-4 (Nov. 1979).

Solar energy research and utilization in China are reviewed. Applications of solar energy which are discussed include solar cookers, hot-water systems, solar dryers, solar-distillation plants, solar-welding devices, and solar-powered lighthouses. Research on silicon cells, passive solar heating, solar thermal-power installations, and spectrally selective coatings is discussed.

206/81 STRATEGY FOR THE DEVELOPMENT OF SOME LOW GRADE THERMAL DEVICES. Y.P. Kedia, R.K. Saksena and C.R. Mitra (Birla Institute of Technology and Science, Pilani (India)). Vol. 1, p. 279-82 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

Feasibility reports of many low-grade thermal devices have been received over the last few years. A panel on solar energy, belonging to the National Council on Science and Technology, expressed optimism in its report about the early commercialization of some of these devices, prominent amongst these being solar water heaters and solar stills. 7 refs.

207/81 NATURAL THERMAL ENVIRONMENTAL CONTROL OF HOUSES IN NORTHERN INDIA. K.D. Mannan, P. Singh and G.S. Dhillon (Punjab Agricultural University, Ludhiana (India)). Vol. 3, p. 1681-5 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

This paper describes an unconventional method of maintaining a moderate thermal environment within a house by using its roof for the storage of hot and cold water in appropriate seasons. During winter, sub-soil water (available at 28 °C) is circulated through a specially designed pipe matrix embedded in the roof slab. The pipe matrix replaces the standard mild-steel reinforcement of the roof slab. The sub-soil water heats the roof slab for radiant heating of the interior. During summer, water in the roof pond is cooled due to night-sky radiation and natural evaporation. This cooled water is circulated through the pipe matrix and is stored in the roof slab. The system has been designed to help the circulation of cooled water by natural convection and a circulation pump has also been provided. Thermal performance of a room having this system is compared with a conventional room and a room having Hay's Skytherm system. 3 refs.

208/81 APPROXIMATIONS TO THE CPC - A COMMENT ON RECENT PAPERS BY CANNING AND BY SHAPIRO. M. Collares-Pereira, J. Gallagher and A. Rabl (Enrico Fermi Institute, University of Chicago, Chicago, IL 60637 (USA)). Solar Energy, vol. 21, p. 245-6 (1978).

Comments and discussions on the recent papers by Canning and Shapiro concerning compound parabolic collectors (CPC) are given. Two mistakes were found in their approximations for producing an ideal CPC. Mistakes in the numerical value of the tracking accuracy and the reflection factor of a normal reverse mirror are also pointed out. 11 refs.

209/81 EXPERIMENTAL AND THEORETICAL INVESTIGATIONS OF AN EAST-WEST ORIENTED PARABOLIC CONCENTRATOR. A.A. Samuel, K.A. Bhaskaran, V. Sriramulu and M.C. Gupta (Indian Institute of Technology, Madras (India)). P. 131-6 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

An east-west oriented parabolic solar concentrator has the advantage that it does not require diurnal tracking. In view of the fact that the reflector is stationary, focusing is not so efficient as with a tracking device, but its efficiency is greater compared to a flat-plate collector. The present paper discusses the theoretical and experimental results obtained during the course of investigation of such a concentrator.

210/81 MANUFACTURE OF FRESNEL LENS BY RADIATION CAST POLYMERIZATION (HŌSHASEN CHŪJŪGONI YORU FURENERURENZUNO SEIZŌ). Ōkubo H., Nishiyama S., Yoshii F., Yoshida K. and Kaetsu I. (Japan Atomic Energy Research Institute, Tōkai-mura, Ibaraki (Japan)). P. 17-20 of Proceedings (Kōen Ronbunshū) of the Third Research Presentation Meeting (Daisankai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nippon Taiyō Enerugii Gakkai) (held Tokyo, Japan, 5-6 Dec. 1977). Japan Solar Energy Society, Bunkyō-ku, Tokyo, Japan (1977). In Japanese.

Because the methyl methacrylate polymer without optical strain and residual stress can be obtained efficiently by a radiation process, the radiation cast-polymerization process was applied to produce Fresnel lenses. The lenses (75-cm side and 150-cm focal length) were manufactured and the relations between the process conditions and the resulting stress, strain and concentration capability were examined.

211/81 A STUDY OF TWO BINARY EUTECTIC ALUMINIUM ALLOYS AS SELECTIVE ABSORBERS FOR SOLAR PHOTOTHERMAL CONVERSION. Y. Chang and P. Bolsaitis (Laboratorio de Procesos Metalúrgicos, Instituto Venezolano de Investigaciones Científicas, Apartado 1827, Caracás 1010-A (Venezuela)). Solar Energy Materials, vol. 4, p. 89-100 (1980).

The fine microstructure found in two eutectic aluminium alloys, Al-6% Ni and Al-33% Cu, was studied in relation to the probable application of these metals as textured selective surfaces. A solar calorimeter was used to determine the bulk absorptivity and emissivity of sample surfaces. For the studied samples, the figure of merit, α/ε, was 2.08 for the Al-Cu alloy and 1.38 for the Al-Ni alloy. It was found that the solidification rate and etching time were the two most important parameters controlling the optical properties, i.e. the α/ε ratio of the surface. 12 refs.

212/81 DEVELOPMENT OF SELECTIVE COATINGS FOR SOLAR PHOTOTHERMAL ABSORBER: ELECTRO-DEPOSITED BLACK NICKEL. A.K. Chhabra, R.P. Agarwal and M.G. Nayar (Bhabha Atomic Research Centre, Bombay (India)). P. 73-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

The results of investigations carried out for the development of an electro-deposited black-nickel selective coating for solar collectors are presented. The effects of different plating parameters such as plating time and current density on the absorptivity in the visible region and emissivity in the infra-red region are discussed. Absorptivity and emissivity values were computed from the spectral reflectivity of the selective surface measured in the visible and infra-red regions, respectively, with suitable spectro-photometers. The results of thermal cycling of the coating samples are also discussed.

213/81 SOLAR SELECTIVE PROPERTIES OF SOME PLATED COATINGS. J. Horner and J. Greene. P. 125-9 of Proceedings of the American Electroplaters Society Coatings for Solar Collectors Symposium (held Atlanta, GA, USA, 9 Nov. 1976). American Electroplaters Society, Inc., Winter Park, FL, USA (1976).

Solar selective properties are studied as obtained from some variations in the nickel-plating process. Data are presented on systems using nickel sulfamate solutions, with and without additives, with various post-treatments to study absorption and emittance properties with different base-metal conditions. Additionally, the properties of nickel systems are compared with coatings on various zinc-plated surfaces.

214/81 TIN OXIDE AS A SPECTRAL SELECTIVE COATING ON ENAMEL (TIOXIDE ALS SPECTRAAL-SELECTIEVE LAAG OP EMAIL). F. Cimonis (TNO Technische Hogeschool, Delft (Netherlands)). Dlein en Keramiek, vol. 29, no. 7-8, p. 130-7. (1979). In Dutch.

Tin oxide can be used in solar collectors as a selective material when it is applied to a black-enamel absorbing surface. The relationships between the spectral selectivity, electric properties and tin oxide film thickness were examined. The tin oxide semi-conductor film was obtained by applying a tin compound to a heated enamel substrate. 3 refs.

B1. RADIATION MEASUREMENT

215/81 CALIBRATION OF SOLAR RADIATION MEASURING INSTRUMENTS. FINAL REPORT. R.J. Bahm and J.C. Nakos (Bureau of Engineering Research, University of New Mexico, Albuquerque, NM (USA)). ALO-5336-T1 (Nov. 1979) 237p. NTIS. US$16.50.

A review of solar-radiation measurement, instruments and some types of errors is given. Procedures for calibrating solar-radiation measuring instruments are detailed. An appendix contains a description of various agencies that calibrate solar instruments and a description of the methods in use at the time this report was prepared.

B2. PHOTOVOLTAIC CONVERSION

216/81 PHOTOVOLTAIC CONVERSION OF SOLAR ENERGY II (LA CONVERSIONE FOTOVOLTAICA DELL'ENERGIA SOLARE II). C. Canali (University Institute for

Physics, Modena (Italy)). Fisica e Tecnologia, vol. 2, p. 99-113. (1979). In Italian.

This article looks at possible solar-cell technology and costs for the years 1976 to 1995. Various types of solar cells which are presently used or are in the course of development are described along with the corresponding process for their manufacture.

217/81 STUDIES ON THE IMPROVEMENT OF PERFORMANCE OF SINTERED Cu_2S/CdS SOLAR CELLS. H. Soha, P. Basu, K. Mukhopadhyaya and S. Sengupta (Department of Physics, University of Kalyani, Kalyani 741235 (India)). Indian Journal of Pure and Applied Physics, vol. 17, p. 215-7 (1979).

Sintered solar cells were studied and results are presented involving the optimization of doping techniques, the effect of In doping, the effect of reheating and cell degradation. Efficiencies of 3-4% were obtained. It was found that In doping accelerates the degradation rate while reheating slows this rate considerably. The principal degradation mechanism was identified to be the diffusion of Cu and Cd into the junction region. 8 refs.

218/81 LOW-COST HIGH-EFFICIENCY SnO_2/n^+-p Si HETEROFACE SOLAR CELL. Takakura H. and Hamakawa Y. (Faculty of Engineering Sciences, Osaka University, Toyonaka, Osaka (Japan)). P. 123-8 of Proceedings of the 10th Conference on Solid State Devices (held in Japan, 1978). 1978.

A new type of low-cost Si heteroface solar cell consisting of SnO_2/p^+-p Si has been developed. Fabrication processes are much simpler than for the ordinary p-n homojunction solar cell with a very high conversion efficiency of 12.9%. The SnO_2 layer acts not only as a heterojunction window, but also as a low-resistance contact and an anti-reflective coating. The optimum design of this type of solar cell has also been investigated and is discussed along with the experimental data. 11 refs.

219/81 FORWARD- AND REVERSE-BIAS TUNNELING EFFECTS IN n^+-p SILICON SOLAR CELLS. G.F.J. Garlick (Department of Electrical Engineering, University of Southern California, Los Angeles, CA 90007 (USA)) and A.H. Kachare. Applied Physics Letters, vol. 36, p. 911-13 (1 June 1980).

Excess currents due to field-assisted tunneling in both forward- and reverse-bias directions have been observed in n^+-p silicon solar cells. These currents arise from the effect of conducting paths produced in the depletion layer by n^+ diffusion and cell processing. Forward-bias data indicate a small potential barrier with height -0.04 eV at the n^+ end of the conducting paths. Under reverse bias, excess tunneling currents involve a potential barrier at the p end of the conducting paths, the longer paths being associated with smaller barrier heights and dominating at the lower temperatures. Low reverse-bias data give energy levels of -0.11 eV for lower temperatures (253-293 °K) and -0.35 eV for higher temperatures (293-380 °K). A model is suggested to explain the results. 16 refs.

220/81 NONREFLECTING VERTICAL JUNCTION SILICON SOLAR CELL OPTIMIZATION. FINAL REPORT, 15 MAY 1976-31 AUGUST 1978. J.H. Wohlgemuth and C.Y. Wrigley (Solarex Corp., Rockville, MD (USA)). AD-A-064431 (Nov. 1978) 71p. NTIS. US$9.50.

This research programme has resulted in the development of high-conversion-efficiency radiation-resistant vertical-junction silicon solar cells. New techniques of oxidation growth and the use of photo-lithography enable the use of an orientation-dependent etch to produce grooves 5-10 μm wide and up to 100 μm deep. These silicon wafers have been processed into solar cells with all processes performed at temperatures compatible with producing high-efficiency solar cells. Theoretical calculations of the expected current as a function of radiation dose have been performed. An explanation of the observed open-circuit voltage is provided. Vertical-junction solar cells have been fabricated with AMO conversion efficiencies greater than 14%. These cells have shown superior radiation resistance. Vertical-junction cells have been fabricated in 2x2, 2x4 and 2x6-cm sizes with no size dependence on efficiency or yield.

221/81 SINGLE CRYSTAL SILICON PHOTOCELLS FOR TERRESTRIAL USE - STATE OF THE ART AND PERSPECTIVES ON THE FUTURE. J. Michel (Laboratoires d'Electronique et de Physique Appliquée, Limeil-Brevannes, Val-de-Marne (France)). Acta Electronica, vol. 20, p. 133-151 (1977). In French.

Methods of reducing the cost of single-crystal silicon photocells with p-n junctions are discussed. Industrial processes employed in manufacturing the silicon cells, including the Czochralski method for pulling single-crystal ingots and the preparation of junction structures, are reviewed. Means of decreasing the cost of manufacturing, such as minimizing the thickness of the silicon wafers, modifying the diffusion, metallization and anti-reflective coating processes, and improving the encapsulation process by increasing photocell density and silicon panel surface are mentioned. Improvement of the short-circuit current is also considered. Costs of single-crystal silicon photocells and photocells produced from polycrystalline silicon are compared.

222/81 LOSS MECHANISM ANALYSIS IN SINGLE-CRYSTAL AND POLYCRYSTALLINE SILICON MIS SOLAR CELLS TO PRODUCE 13% EFFICIENCY. K. Rajkanan, W.A. Anderson and G. Rajeswaran (Department of

Electrical Engineering, State University of New York at Buffalo, Amherst, NY 14206 (USA)). Solar Cells, vol. 3, p. 17-25 (1981).

Current mechanism studies have revealed band-to-band tunneling and surface-state currents to control chromium MIS solar cell behaviour. This information, together with intrinsic and design-related loss analysis, was used to optimize the design of the chromium MIS solar cell. It is shown that a high-efficiency cell can be produced when the interface and grain-boundary state densities are below 10^{12} cm^{-2} eV^{-1}, the interface oxide thickness is 12-18 Å, the grain size is above 40 μm and the doping density is 10^{16}-10^{17} cm^{-3}. This computer-aided design was used to fabricate a 13.2% experimental solar cell in agreement with the predicted performance. 10 refs.

223/81 REDUCTION OF SURFACE RECOMBINATION VELOCITY OF SILICON SURFACES BY SnO_x FILMS. I. Chambouleyron, E. Saucedo and J. Montoya (CIEA-IPN, México (Mexico)). P. 647-53 of Proceedings of the Second E.C. Photovoltaic Solar Energy Conference (held West Berlin, Fed. Rep. of Germany, 23 Apr. 1979). R.J. Van Overstraeten and W. Palz (eds.), D. Reidel Publishing Co., Hingham, MA, USA (1979).

Structural, optical, and electrical characteristics of SnO_x films obtained by the chemical-spray method and the passivation effect which they provoke when deposited on conventional Si solar cells are reported. Experimental work was carried out to elucidate the actual influence of H and Cl atoms, liberated during the deposition process, at the SnO_x-Si interface. Atomic hydrogen is shown to play the main role in Si surface passivation. It has been found by SIMS analysis that hydrogen diffuses in the silicon lattice after SnO_x deposition. This fact might produce changes in the transport properties of the diffused region of silicon solar cells and contribute to the large increases in short-circuit current found after coating.

224/81 DETERMINATION OF THE MINORITY CARRIER DIFFUSION LENGTH IN SILICON SOLAR CELLS. A.K. Vaseashta, J.D. Arora and P.C. Mathur (University of Delhi, Delhi (India)). International Journal of Electronics, vol. 46, p. 529-33 (May 1979).

Minority-carrier diffusion length in the base region of silicon solar cells, fabricated by a diffused-junction technique and having a resistivity in the range 0.1-10 Ω/cm, has been measured by studying the spectral dependence of the observed variation of minority-carrier diffusion length and lifetime with the doping level of the base region.

225/81 OPTIMIZATION OF ELECTRICAL AND OPTICAL CHARACTERISTICS OF SILICON PHOTOELEMENTS DESIGNED FOR PHOTOTHERMAL CONVERTERS OF CONCENTRATED SOLAR RADIATION. M.M. Koltun and I. Gavrilova. Гелиотехника, no. 1, p. 3-12 (1978) [English Translation in Applied Solar Energy]. In Russian.

A study was made of means of optimizing the electrical and optical characteristics of silicon photo-elements for operation at increased concentrations of solar radiation in photo-thermal converters. The spreading resistance of the alloyed layer determines the efficiency of the silicon photo-elements. Data are presented from studies of the influence of the thickness of this layer, the configuration of the contact grid, the transmitting coatings and metal layers on the efficiency of the Si elements at various concentrations. Measurements indicated that at a 30- to 70-fold concentration the efficiency reaches approximately 12%. The theoretical and experimental data indicate that two types of planar silicon photo-elements can be used for photothermal units, with an ordinary transmitting coating and with a selective black and white coating. The former have better electrical characteristics and the latter, a better optical coating. Both can be used depending on the operating conditions of the required photo-elements.

226/81 WIDE BAND WIDE ANGLE REFLECTION-REDUCING COATINGS FOR SILICON CELLS. S.F. Pellicori (Santa Barbara Research Center, Goleta, CA 93017 (USA)). Solar Cells, vol. 3, p. 57-63 (1981).

A programme for the design, deposition and environmental evaluation of coatings for silicon cells is reported. This programme had as its objectives the optimization of a multilayer coating for wide acceptance angles, extended spectral response and space-qualified environmental durability on covered cells. Two- and three-layer designs were evolved and subsequently, deposited and evaluated. A two-layer design using CeF_3 (quarter-wave optical thickness (QWOT) at 710 nm) and TiO_2 (QWOT at 682 nm, innermost) reduced the reflectance average to 3% or below between 550 and 1000 nm wavelength. The improvement in cell-power output over a conventional single-layer coating was about 8%. All environmental tests were passed by this two-layer combination. 5 refs.

B3. ACTIVE THERMAL SYSTEMS

227/81 SOLAR WATER PUMPING SYSTEM. M.G. Clemot (Sofretes, Montargis (France)). P. 111-20 of Soltech '78 (Proceedings of the Middle East Solar Technical Exhibition and Conference, held Manama, Bahrain, 21 April 1978). UK-ISES, London, UK (1978).

The basic components of a solar water pump are described and practical applications are discussed, including uses in villages for livestock and irrigation. Several solar-pump demonstration projects are briefly outlined.

228/81 DEEP-WELL SOLAR IRRIGATION EXPERIMENT. R.L. Alvis. Vol. 4, no. 3, p. 8-11 of Sandia Technology. SAND-78-2041 (Nov. 1978) 9p. NTIS.

The location and detailed layout of the solar-irrigation project on the Dalton Cole Farm near Coolidge, Arizona, USA, are shown. The design for this deep-well irrigation experiment uses a distributed field of trough-type solar collectors and an organic Rankine-cycle heat engine.

229/81 SOLAR COLLECTOR PANEL AND REFRIGERATION SYSTEM OPERATED THEREBY. T. Kay. US Patent 4,126,014 (21 Nov. 1978) 6p. File date: 9 May 1977.

Solar energy is collected by a plate-shaped panel of pliable-plastic construction. The two major walls of the panel, whose edges are sealed to each other, consist of transparent and black plastic, respectively, and enclose a cavity. The panel is expanded by air introduced by a blower and discharged through a restricted outlet. A radiation trap of pleated transparent-plastic sheeting is fastened in the cavity to the transparent wall. The hot air discharged from the panel when it collects solar radiation provides all the necessary energy for operating an absorption-refrigeration system of the electrolux type.

230/81 LOW COST SOLAR WATER HEATING FOR LARGE SCALE APPLICATIONS. V.R. Kane. P. 158-62 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

One of the major potential applications of solar energy is in the production of hot water. Hot water is extensively used for various operations in industries and elsewhere. The possibilities of using low-cost solar water heating for large-scale applications are discussed. A year's experience with the operation of black-bottom shallow solar ponds (BBSSP) for heating water using commercially available plastics is presented. Comparative studies on the operation of many 0.4-m^2 area units have been carried out. The various types of degradation and the durability of the plastics used have been studied. Technical and economic feasibility of water heating on a large scale by scaling up the small unit has been investigated. The possibility of installing these low-cost systems on industrial sheds to provide hot water is discussed. Estimates on the costs have also been made.

231/81 OPEN ABSORPTION SYSTEM UTILIZING SOLAR ENERGY FOR AIR CONDITIONING. G. Grossman and I. Shwarts (Israel Institute of Technology, Haifa (Israel)). P. 641-47 of Proceedings of the Conference on Heat and Mass Transfer in Buildings (held Dubrovnik, Yugoslavia, 29 Aug. 1977). Hemisphere Publishing Corp., Washington, DC, USA.

The possibility of providing the cooling needs of buildings by means of solar energy has a large potential for energy conservation. A number of solar air-conditioning systems have been experimented with, most relying on solar heat to power a closed-absorption or a steam-ejector type cooling device. These systems normally have a low coefficient of performance when used with a low-temperature heat source such as flat-plate solar collectors. The present work is a study of an air-conditioning system based on dehydration of the air in an open absorption system where the desiccant solution is regenerated by solar energy. Ambient air is dehydrated by means of the desiccant. The dry air is cooled back to ambient temperature by indirect heat exchange, then cooled further by a combination of evaporative and mechanical cooling. The advantages of the system are that the energy to power the system can be supplied at temperatures not higher than 71 °C, which are easily obtained with solar energy, and that the entire latent heat can be removed at temperatures of 29 °C, compared with latent-heat removal temperatures of 1.1 to 5 °C found in mechanical air-conditioning systems.

232/81 SOLAR PONDS FOR INDUSTRIAL PROCESS HEAT. K.C. Brown, M. Edesess and T.S. Jayadev (Solar Energy Research Institute, Golden, CO (USA)). SERI/TP-351-460 (1979). Solar Energy Research Institute, 1536 Cole Boulevard, Golden, CO 80401, USA. 8p.

Solar ponds offer perhaps the simplest technique for conversion of solar energy to thermal energy, which can be used for industrial process heat (IPH). It is unique in its capability to act both as a collector and a storage medium. Further, the cost of the solar pond per unit area is less than any active collectors available today. A combination of these economic and technical factors make solar ponds attractive as a fuel saver in IPH applications. This paper presents detailed calculations of solar ponds for two specific applications: providing hot water for aluminium-can washing in a manufacturing plant and hot water for washing in a large commercial laundry. With the help of computer codes developed at SERI for other solar IPH systems, it is shown that solar ponds are far more cost effective than any other solar IPH technology for these applications. 10 refs.

233/81 DESIGN AND TEST OF NON-EVACUATED SOLAR COLLECTORS WITH COMPOUND PARABOLIC CONCENTRATORS. A. Rabl, J. O'Gallagher and R. Winston (Enrico

Fermi Institute, University of Chicago, 5630 Ellis Avenue, Chicago, IL 60637 (USA)). Solar Energy, vol. 25, p. 335-51 (1980).

The intermediate range of concentration ratios (1.5-10X) which can be achieved with compound parabolic collectors (CPCs) without diurnal tracking provides both economic and thermal advantages for solar-collector design even when used with non-evacuated absorbers. The present paper summarizes more than 3 years of research on non-evacuated CPCs and reviews measured performance data and critical design considerations. Concentrations in the upper portions of the practical range (e.g. 6X) can provide good efficiency (40-50%) in the 100-160 °C temperature range with relatively frequent tilt adjustments (12-20 times per year). At lower concentrations (e.g. 3X) performance will still be substantially better than that for a double-glazed flat-plate collector above about 70 °C and competitive below, while requiring only semi-annual adjustments for year-round operation. In both cases the cost savings associated with inexpensive reflectors, and the optimal coupling to smaller, simple inexpensive absorbers (e.g. tubes, fins, etc.) can be as important an advantage as the improved thermal performance. The design problems for non-evacuated CPC collectors are entirely different from those for CPC collectors with evacuated receivers. For example, heat loss through the reflector can become critical, since ideal CPC optics demands that the reflector extend all the way to the absorber. Recent improvements in reflector surfaces and low-cost anti-reflection coatings have made practical a double-glazed non-evacuated CPC design. It is calculated that a 1.5X version of such a collector would have an optical efficiency $\eta_0 = 0.71$, a heat-loss coefficient $U = 2.2\ W/m^2\ °C$ and a heat-extraction efficiency factor $F \geq 0.98$, while requiring no tilt adjustments. 21 refs.

234/81 PERFORMANCE TEST OF A NON-PARABOLIC ASYMMETRICAL SOLAR CONCENTRATOR. C.T. Leung (Department of Mechanical Engineering, University of Hong Kong, Hong Kong (UK)) and Y.B. Ng. Regional Journal of Energy Heat Mass Transfer, vol. 2, no. 4, p. 229-33 (1980).

This paper reviews the geometrical optics for constructing the reflector of a non-parabolic asymmetrical solar concentrator. A prototype concentrator of this kind has been constructed with a concentration ratio of 4.07 and a theoretical optical efficiency $\eta_0 = 0.67$. Standard performance tests on such a concentrator indicate a heat-loss coefficient $U = 4.35\ Wm^{-2}\ °C^{-1}$ and a heat-extraction efficiency factor $F = 0.92$. 12 refs.

235/81 PERFORMANCE OF A HONEYCOMB TYPE FLAT-PLATE COLLECTOR WITH SERPENTINE TUBE. A.S. Shinde and G.K. Sharma. P. 47-52 of the Proceedings of the Fourth National Heat and Mass Transfer Conference (held Roorkee, India, 21-23 Nov. 1977). Sarita Prakashan, Meerut, India.

The efficiency of a solar collector can be improved by reducing the heat losses from the hot absorber plate to the cooler surroundings. The present study deals with such a reduction by using a honeycomb structure between the glass cover and absorber plate. The performance of different types of honeycomb structures (at various values of honeycomb L/d ratios) has been studied experimentally and results are discussed.

236/81 PERFORMANCE OF AN INEXPENSIVE CONSTANT FLOW SOLAR COLLECTOR/STORAGE SYSTEM IN GROUND. M.S. Sodha, A. Srivastava, G.N. Tiwari, S.C. Kaushik and M.A.S. Malik (Indian Institute of Technology, New Delhi (India)). International Journal of Energy Research, vol. 3, no. 4, p. 379-87 (Oct.-Dec. 1979).

This paper presents an analysis of the performance of an inexpensive constant-flow solar collector-storage system which has been validated by experiments. The system consists of a network of plastic pipes buried in the ground, the top surface of the ground being blackened by blackboard paint spray and suitably glazed. The heat can be extracted by circulating a fluid in the pipes at a constant flow rate. It is seen that for a 7-cm depth of the plane of heat retrieval and 8 l/min flow rate of water, the collection efficiency of the system is 20.0%. The efficiency increases with flow rate and decreases with the depth of the plane of heat retrieval. 4 refs.

237/81 RESIDENTIAL SOLAR DESIGNS USING PYRAMIDAL OPTICS SOLAR SYSTEMS. C. Mezoff. P. 183-90 of Proceedings of the Second Conference of the New England Solar Energy Association (held Hartford, CT, USA, 8 Sept. 1977). New England Solar Energy Association, Brattleboro, VT, USA.

The pyramidal-optics system is a low-gain optical solar-collection system which uses inexpensive flat-mirror surfaces enclosed in an attic space to achieve a concentration factor of up to four. This concentration reduces the collector requirement by a factor of four and results in a significant reduction in cost for flat-plate receivers and associated plumbing with less consumption of strategic materials. By placing the absorbers within an attic space, they are protected from rain, ice, snow, and dirt so that the collectors need not be constructed to withstand severe environmental assaults. By reducing the receiver area by a factor of four, the solar flux per unit area is increased by a factor of three, whereas the radiant, conductive, and convective losses which are proportional to absorber surface area, are not similarly increased. This results in a net improvement in performance.

238/81 POTENTIALITY OF GLASS IN HARNESSING

SOLAR ENERGY. B. Mazumder (Central Glass and Ceramics Research Institute, Calcutta 700032 (India)). Transactions of the Indian Ceramics Society, vol. 38, no. 1, p. 49-54 (1979).

This article shows how glass can be used in the various parts of a solar energy heating system including the collector, heat exchanger and the storage unit. 11 refs.

B4. PASSIVE THERMAL SYSTEMS

239/81 PASSIVE SOLAR HEATING - IMPROVED LIVING CONDITIONS FOR A HIGH ALTITUDE POPULATION. Appropriate Technology, vol. 7, no. 3, p. 7-9 (1980).

A sketch is given of an average village in the Ladakh region of India, and the problems involved in heating homes to provide both comfort and good health during the extremely cold winters. The development and installation of two Trombe-wall passive solar-heating systems for these houses are outlined. The cost of building a Trombe wall-system in Ladakh is approximately Indian rupees 9000 (US$1,125) for room sizes of 21 m^2.

240/81 SOLAR SEA WATER DESALINATION FOR ARAB COUNTRIES. K. Schubert. Dornier-Post (English Edition) no. 1, p. 60-1 (1979). In German.

This article reports on a task commissioned to the firm Dornier to set up a prototype plant for solar sea-water desalination in Jordan. The solar-thermal sea- and brackish-water desalination plant described here works according to the evaporation principle and is fitted with heat-pipe collectors. The drinking-water production of the pilot plant is to reach 200 liter/h at first. The aim of the project is, furthermore, to inform Jordanian scientists and technicians about this technology so that similar plants will be able to be developed.

241/81 CONCERTED EFFORTS TO IMPROVE THE EFFICIENCY OF MULTI-SURFACE SOLAR STILL. S.P. Anand (National Institute of Oceanography, Goa (India)). P. 238-41 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

A 50% increase in the quantity of fresh water from the multi-surface solar still, without effecting any increase in the surface area occupied by the still, has earlier been reported by the same author. In order to further increase the input of heat to the system, and thereby to increase its overall efficiency, some efforts were made toward the application of lamp-black particulates in free form over the surface of water or admixed with other lighter particles of similar granular size. The results have been compared with the earlier heat-absorption efficiencies estimated separately.

242/81 SOLAR DESALINATION. B.E. Swaidan (Navy Construction Battalion Center, Port Hueneme, CA (USA)). Vol. 2, p. 951-88 of Alternative Energy Sources (Proceedings of the Alternative Energy Sources Symposium, held Miami Beach, FL, USA, 5 Dec. 1977). T.N. Veziroglu (ed.), Hemisphere Publishing Corp., Washington, DC, USA (1978).

Various techniques and geometries for solar desalination are discussed that have direct impact for use at naval activities. Concept development of solar stills with capacities ranging from several liters per day to 200,000 liters per day are presented. Emphasis is focussed on obtaining high efficiencies by recapturing the heat of condensation of the product water vapour. Other concepts utilizing solar energy to augment existing technology are also presented, such as: solar preheating of seawater for a multi-stage flash unit or solar to electric power conversion to drive a vapour compressor and a seawater pump for a vapour-compression unit. This study is being undertaken to provide the US Navy fresh water at remote bases. Accordingly, the conceptual development of these solar stills must reflect the Navy requirements by conforming to the containerization trend. Therefore, the portable stills being envisioned must be lightweight, efficient, durable, and must readily be erected or dismantled.

243/81 SOLAR-BASED AGRICULTURAL SYSTEMS FOR THE MIDDLE EAST. A.A.M. Sayigh (University of Riyadh, Riyadh (Saudi Arabia)). P. 61-73 of Proceedings of the Soltech '78 Conference (held Manama, Bahrain, 24 April 1978). UK-ISES, London, UK.

Various systems based on environmental control are discussed. The use of shelter (natural or artificial), selective shelter, and special greenhouses are discussed in relation to a variety of climatic conditions. The use of passive cooling coupled with the Ruthner principle are studied particularly with regard to their future role in continuous agricultural production. Some examples of existing greenhouses in the neighbourhood of Riyadh are discussed. Several unusual designs, such as those developed by Brace Research Institute and Polysolar Company, are fully discussed. In the concluding remarks several recommendations are mentioned and all systems are compared.

244/81 SOLAR HEAT DRYING OF GRAINS. Nakagawa K. (Faculty of Agriculture, Mie University, Tsu, Mie (Japan)). Nōgyō Oyobi Engei (Agriculture and Horticulture), vol. 54, no. 1, p. 174-80 (1979). In Japanese.

Various methods for the utilization of solar heat to dry grains, including natural and artificial drying methods, are described. A solar-heat collector with heat-collecting plates is utilized for this purpose. The air circulates from the collector to the dryer in which the grain is fed. The relations between air-flow rate, total collected heat and heat performance are shown as well as various structures for the heat collector. Experimental data are given for grain-drying processes. 15 refs.

245/81 INTENSIFYING THE KILLING AND DRYING PROCESS FOR SILK COCOONS WITH THE AID OF SOLAR ENERGY. R. Bairamov, Z. Muradov and R. Baidzhanov (Physico-Technical Institute, Ashkhabad, Turkmen SSR (USSR)). Applied Solar Energy, vol. 13, no. 4, p. 55-6 (1977)[English translation of Гелиотехника, vol. 13, no. 4, p. 70-2 (1977)].

An experimental solar-drying unit for cocoons of the mulberry silkworm is described. Its operation in the village of Oktyabr'sk, Chardzhouskii District, Turkmen SSR, USSR, yielded positive results, with better raw-material quality than with chemical killing. It was possible to save energy and shorten the drying process.

246/81 IMPLEMENTATION OF A SOLAR POND GREENHOUSE HEATING SYSTEM. T.H. Short, P.C. Badger and W.L. Roller (Ohio Agricultural Research and Development Center, Wooster, OH (USA)). P. 55-9 of Proceedings of the Third Annual Conference on Solar Energy for Heating Greenhouses and Greenhouse Residents Combination (held Collins, CO, USA, 2 Apr. 1978). NTIS. US$8.50 for complete proceedings (CONF-7804110).

Pond construction, gradient establishment and maintenance, control of solar-pond pH and microorganism growth, and heat removal are discussed.

247/81 COST REDUCTIONS AND PERFORMANCE IMPROVEMENTS FOR SHALLOW SOLAR PONDS. A.B. Casamajor, A.F. Clark and R.E. Parsons (University of California, Livermore, CA (USA)). Vol. 1, p. 34.12-34.16 of Proceedings of the 1977 Annual Meeting of the American Section of the International Solar Energy Society (held Orlando, FL, USA, 6 June 1977). C. Beach and E. Fordyce (eds.), American Section of the International Solar Energy Society (1977).

Recent efforts to commercialize the shallow solar-pond concept have demonstrated a need to reduce costs and improve performance to compete with fossil fuels. Several simple design changes will reduce the system cost by 15%. Other changes that will substantially reduce costs are possible but need further evaluation. Reflectors along the north edge of a pond to augment its winter performance have been evaluated experimentally.

C. BIOCONVERSION ENERGY

248/81 SOLAR ENERGY: BIOMASS (L'ENERGIE SOLAIRE: BIOMASSE). Commissariat à l'Energie Solaire, Paris (France)). 2 Volumes. Commissariat à l'Energie Solaire, Paris, France (1979-80).

This article is an account of a study on different aspects of biomass and its use as a source of energy. Included is an appendix listing the names of research organizations in this field.

Cet article présente une étude des divers aspects de la biomasse et de son utilisation énergétique. Une liste des organismes de recherche actifs dans ce domaine est donnée en appendice.

249/81 BIOLOGICAL SOURCES OF ENERGY. P.L. Rogers (School of Biological Technology, University of New South Wales, Kensington, NSW (Australia)). Australian Natural History, vol. 19, p. 372-5 (1979).

A brief presentation is made of the production of ethanol by fermentation and of the anaerobic digestion of agricultural and animal wastes. Some data are given for the production of hydrocarbons by Botryococcus braunii. 6 refs

250/81 MICROBIAL PRODUCTION OF ENERGY SOURCES FROM BIOMASS. R.C. Righelato (Tate and Lyle, Reading, Berkshire (UK)). Philosophical Transaction of the Royal Society of London, A, vol. 295, no. 1414, p. 491-500 (1980).

This contribution describes the processes involved in the production of ethanol by fermentation and of methane by the anaerobic digestion of biomass. An economic analysis of plants based on these processes is included. 32 refs.

C1. BIOMASS PRODUCTION AND CONVERSION

251/81 FIREWOOD CROPS. Advisory Committee on Technology Innovation (Board on Science and Technology for International Development, Commission on International Relations, National Academy of Sciences, Washington, DC (USA)). National Academy of Sciences, Washington, DC, USA (1980).

This report does not suggest a solution to the entire firewood crisis but examines one part

UNCNRSE

CONFERENCE NEWS 6

SUMMARIES: AD HOC EXPERT GROUP REPORTS

Complementing the substantive preparations of the technical panels, the Ad Hoc Groups of Experts contributed their findings and recommendations for synthesis and submission to the Preparatory Committee. Following are brief summaries of the reports.

FINANCING

It is difficult to arrive at evaluative criteria for determining the value of investments in renewable energy sources because of the role of energy as a factor of production and the negative relationship manifested between the depletion/regeneration ratio of existing conventional energy sources. The importance of NRSE lies in the assumption that it can play a role in sustaining world energy reserves. This would then require a readiness to apply more comprehensive cost-evaluative criteria to appraising renewable energy resources financially. Current financing of energy production poses a major problem for the oil-importing developing countries, where existing balance of payments threaten to become unmanageable. Attempts to estimate future financial requirements for energy development encounter difficulties which stem from complex conceptual and statistical uncertainties concerning the rates and patterns of global growth and consumption. Notwithstanding these formidable difficulties, projections on future energy investment requirements for developing countries have been arrived at by the World Bank, UNCTAD, and UNIDO. Obviously, the responsibility for economic and social development reposes in the national governments. Therefore, the initiative for energy resources development (planning, co-ordination and financing) follows suit. However, the international community must stand ready to assist developing countries in their effort to accelerate their energy transition.

External financing is presently derived from multilateral development institutions, member countries of the Development Assistance Committee of the OECD, and from the OPEC Fund for International Development. Providing half of the total lending commitments to oil-importing developing countries for commercial energy development in 1978-80 (approx. $5 billion), the World Bank, possessing detailed knowledge of local conditions, resource priorities and interest in activities in the field of NRSE, acts as a catalyst for co-financing. The regional and sub-regional development banks of Africa, Asia, and Latin America have the tripartite potential to make available their own resources, generate additional funds from member states, and attract increased amounts of external bilateral and multilateral resources for NRSE. The UNDP has allocated financing of activities in the field of energy amounting to $5 billion for 1982-86. In 1979 members of the DAC committed $1.4 billion as official development assistance (ODA) and export credit of roughly $10 billion for energy development in developing countries, but NRSE was only a marginal part of this external financing support. Bilateral and multilateral aid commitments from OPEC countries to energy development were around $850 million in 1978 and $530 million in 1979 (16% of their total assistance programmes).

The available estimates suggest that future energy financing requirements will fall significantly short of prospective supplies of funds unless steps are taken to close the financing gap. Political and capital restraints have diminished external financial support for energy development from International Development Association, DAC countries, and regional and sub-regional banks thereby cutting down soft loan funding. While every effort must be made to reach the 0.7% ODA target by 1985, there is a parallel need to look to non-budgetary sources of finance with interest subsidy components that provide desirable and appropriate concessions for investments in NRSE.

In line with the theme of the Conference, the Group on Financing recommended that oil-importing developing countries strengthen their capital base and expand co-financing activities; that DAC countries should continue to increase their ODA; that assistance should be increasingly concentrated on the poorer developing countries. It is further recommended that the development of NRSE technology be undertaken by the entire range of UN institutions and agencies, particularly the proposed energy affiliate of the World Bank and the International Fund for Agricultural Development.

EDUCATION AND TRAINING

Because of the need to adapt, modify, and develop the necessary technologies to suit local conditions the extent and rate of utilization of NRSE in developing countries depend, to a large degree, on the education and training of a wide spectrum of persons, ranging from policy-makers to the general public.

The Group on Education and Training noted that education and training cannot be considered independently of other needs. For example, training is needed for personnel working in research and development programmes and in the local industry manufacturing NRSE systems. Also it is very difficult in practice to distinguish between the education of future users of NRSE and the flow of information which is simultaneously provided to the public about the advantages and constraints of

This section of *ASSET (Abstracts of Selected Solar Energy Technology)* is devoted to the UN Conference on New and Renewable Sources of Energy and is published by the UN University with the co-operation of the UNCNRSE Secretariat and the UN Division for Economic and Social Information of DPI.

these sources and the techniques for their use. There are many other linkages of this kind, and it is important that education and training be seen as one element in an integrated programme for the development and use of NRSE.

The Group considered each of the energy sources on which the UN Conference will focus, and made specific proposals for each. Technical training at the national level is a need common to virtually all of the NRSE. Developing countries should be assisted in the establishment of courses for training technicians and, where appropriate, professionals and scientists; for equipping local technicians and skilled labour with additional skills related to these sources; and for training teachers and trainers and providing them with teaching materials. Because there are very few institutions in developing countries capable of providing specialized training in the use and development of many of the NRSE, it was recommended that institutions be established on a regional basis to develop personnel capable of initiating and managing modest projects based on the employment of these sources. A third proposal common to many of the NRSE was to increase the strength and number of UN-sponsored fellowship programmes for training in NRSE. In addition, the Group made several proposals specific to individual sources such as the strengthening of the capacity of national agricultural and forestry extension services to promote biomass production for energy.

The Group found that while training needs are substantial and may be critical to success in many cases they are also manageable provided that substantial commitments are made at the national and international levels. Further, it was recognized that the opportunities for employment that both small-scale and large-scale NRSE projects can offer represent a significant contribution to the development process itself in many countries. The skills required for these energy technologies represent a realistic and valuable opportunity to upgrade the qualifications and capabilities of large numbers of people as an important part of development activities.

The Group made nineteen specific recommendations concerning education and training. At the national level, these included the establishment or strengthening of appropriate structures for science and technology, the establishment of energy policies, a comprehensive assessment of resources of NRSE, and the provision of education and training to enable such inventories to be undertaken. At the international and regional levels, courses for policy-makers and energy planners should be established, and assistance should be given to national and international non-governmental organizations to promote the development and utilization of NRSE. In addition to these actions, the Group made several general recommendations including the development of appropriate model curricula and teaching aids for use in national education systems and the facilitating of the exchange of information on educational systems, training programmes, and technical experience.

RESEARCH AND DEVELOPMENT AND TRANSFER OF TECHNOLOGY

A review of current R and D activity shows that while the major activity is still concentrated in the industrialized countries, a significant but still small amount of work is being undertaken by developing countries. It is imperative that developing countries undertake increasing amounts of R and D activity in the area of the NRSE for several reasons. First, there are many applications of these alternative sources of energy that are of significant interest only to the developing countries. Second, the design of systems for use in the industrialized countries is geared to minimizing labour inputs for both their production and operation. Clearly there will be a need to choose, adapt, and even improve such technologies for use in developing countries. Lastly, solar energy systems present a new and unprecedented trend. Most technologies that had been transferred to developing countries had saturated local markets in industrialized countries, thus the manufacturing firms seek additional markets. However, some industrialized countries view the Third World as a major near term market for selected new and renewable technologies prior to widespread use in their own countries. Clearly such systems cannot be developed, exclusively, in the socio-cultural setting and environment of the industrialized countries with the assurance that they will be suitable for use in the developing nations. The acceptance by developing countries of those technologies developed in industrialized countries implies the capacity of developing nations to assess, select, successfully negotiate, purchase, and adapt such technologies. Thus, there is a need to identify and assess alternative channels for the transfer of NRSE technologies, and to formulate and implement technology policies.

The Group on Research and Development noted that research, development, and demonstration in the developing countries will be an integral part of the technology transfer process both between industrialized and developing countries and between the developing countries themselves. There are several reasons for this. First, research, development, design, engineering, and demonstration in developing countries contribute to manpower training and institution building and thereby help to establish a core of skilled personnel capable of evaluating and demonstrating the suitability of both domestically produced and imported technologies. Second, it helps to establish a local presence for the technologies, making it much more likely that policy planners will incorporate the selected alternative energy technologies in their development plans. Third, equipment which results, at least in part, from locally initiated R and D will be more consistent with national needs, more amenable to local manufacture, and more likely to come into widespread use. Lastly, the undertaking, individually or in collaboration with other developing countries, of research, development, and demonstration activities will minimize the risk of developing countries becoming captives of a relatively small number of transnational corporations based in the industrialized countries.

The Group concluded that it is important that the developing countries assume a major role in applied research, development, and demonstration for NRSE technologies in several areas: generating detailed identification and analysis of specific developing country needs and the engineering of the systems required; testing of the technical and economic viability of the technologies and assessing their social and environmental impacts; assisting local manufacture; and implementing research and action programmes to overcome social or cultural barriers.

In the area of national energy assessment and planning, the Group recommended that a task force be set up under UN auspices and funding to report on the progress of current assessments and to identify the additional work needed. The Group also recommended that UN Regional Commissions continue their work in establishing regional centres for the transfer of technology, and that a task force be set up under UN auspices to determine the need to establish new centres possibly devoted to specific areas of NRSE. An internationally funded and co-ordinated R and D programme on biomass energy systems should be established and a special task force of experts in biomass energy assembled. The Group urged that task forces of international experts be formed to undertake the establishment of a test programme comprising technical specifications cost forecasts and organizational structure.

INFORMATION FLOWS

The Group on Information Flows identified major user groups and considered their information requirements with respect to scope, nature and type of information, current information exchange and dissemination activities, and costs and financing mechanisms for information delivery and access, before making an assessment of current information use and supply capabilities. Finally, the Group identified measures to improve the present condition regarding: information content; access mechanisms; its utilization; and international exchange and dissemination.

Since information concerning NRSE is quite inhomogeneous and scattered throughout many fields of specialization, it is not feasible to group them all together under a single new information system or service. Also, they cannot logically be separated from other alternative energy sources including non-renewable sources. Therefore, the Group suggested the formation of a flexible information network based on existing information facilities. The Group also suggested that effective financing mechanisms be established to ensure that necessary resources are made available at the national, regional and global levels. As an example, it recommended that governments consider allocating a specific percentage of funds earmarked for developing NRSE to promote information flow.

Based on the premise that the effective flow of information both at regional and global levels depends heavily upon the information handling capabilities at the national level, the Group agreed that efforts should be concentrated on providing support at this level. It was, therefore, suggested that a detailed analysis of national information infrastructures be prepared with a view towards: the development of specialized national information centres; strengthening of the basic components of the national information system; and strengthening capabilities for planning and implementing education and training programmes.

In suggesting lines of action at the regional level, the Group noted the existence of a number of regional information-exchange mechanisms which have been established through inter-governmental co-operation. The Group recognized the fact that regional activity is a viable way to involve small developing countries which stand to benefit from the introduction of NRSE applications but which have technological resources below the threshold for effective national action. Two recommendations suggested are: the allocation of funds required within the budget of regional inter-governmental bodies such as the regional economic commissions to promote effective information flows so that national and regional information activities receive sufficient financial support; and a critical comprehensive review of institutions and activities engaged in generating, collecting and disseminating information on NRSE in each region in order to identify and strengthen institutions capable of serving as regional information focal points. In considering the measures to be undertaken at the global level, the Group recognized the importance of the varied nature of NRSE and the heterogeneous information requirements of individuals who are engaged in the development of these energy sources. It was concluded that most of the information gathering and dissemination activities might best be carried out separately for each type of energy - perhaps even in different institutions according to the availability of relevant substantive expertise, capabilities and support. The Group recommended that international organizations entrusted with the responsibility of formulating and implementing the over-all programme of work for NRSE should compile and maintain an inventory of currently available information systems and services for NRSE, and convene consultative meetings at which ways and means of improving international co-operation can be devised and organized. The Group also suggested that highly focused feasibility studies could be undertaken with a view towards establishing linkages among existing information analysis and dissemination centres. It was concluded that the information programme planned by UNESCO based along these lines should receive the support available for this effort.

RURAL ENERGY INCLUDING UTILIZATION IN AGRICULTURE

There has been a slow build up of a critical situation in the rural sector of developing countries over many years, long predating the 1973 "oil crisis". This energy crisis affecting about 2 billion people directly is centred around the use of wood, organic wastes, and muscle power. The poverty characteristic of the rural sector is a reflection and a consequence of its great dependence on these non-commercial sources of energy. Moreover, the developing countries with the lowest living standards are distinguished by their low level and inefficient use. Notwithstanding the fact that as much as 95% of the energy in the rural area comes from these energy sources, the energy requirements of the rural sector, predominantly for cooking and heating, account for only about one fifth of the total consumption of the developing countries.

The Group on Rural Energy noted the heavy reliance of rural populations on fuelwood. In 1980 the minimum energy requirements of approximately 90 million rural people in developing countries were not met, and some 833 million additional rural people and 166 million urban dwellers lived in situations in which they were using fuelwood supplies faster than they were replenished. Agriculture is the major economic activity using energy in rural areas. However, it is also the major supplier of energy for rural households, rural industries and services, and its own use. Thus, it is important to consider the possibilities of increased use of agricultural residues and crops grown specifically for their energy content.

There are a multiplicity of problems and constraints associated with the development, supply, and utilization of NRSE in the rural areas. These include the lack of policies and strategies, infrastructure, acceptable loan and investment terms, adequate research, and available information. In solving these problems and overcoming the constraints several factors must be borne in mind. First, effective development and management of rural-energy use and production can be best achieved within the framework of rural energy systems. Second, while most rural energy technologies have reached sufficient maturity, additional effort is required to optimize their performance. Third, there are certain inadequacies and drawbacks in the use of new energy technologies in rural areas, and these become more serious with increased complexity and intensity of use. Finally, there is need to further elaborate the integrated rural energy concept which considers the farm and the rural community as an energy system capable of producing the energy to meet its total energy demand by appropriately combining renewable and conventional energy technologies.

The Group made several recommendations concerning rural energy. The principal recommendation is that national governments, the UN system, and other regional and international agencies commit themselves to strengthening the position of rural people in their access to sufficient supplies of energy. This is necessary both to prevent the further deterioration of the currently inadequate levels and to allow genuine rural development. The Group noted that it is necessary to develop and maintain rural energy policies and programmes for the provision of adequate supplies of energy for rural development programmes. These actions are the responsibility of national governments which should raise the general awareness and commitment of all concerned. Institutions must be strengthened, or created where necessary, for the identification of rural energy development needs and the design, selection, and implementation of rural energy programmes. At the national level, these actions should be co-ordinated by the appropriate department or ministry. A commitment must be made to considerably increase the level of financial resources in line with the urgency and scale of the rural energy problem. International agencies should take further steps to develop emergency funding mechanisms which meet the particular problems of countries with acute rural energy shortages. National governments should increase the levels of funding earmarked for the rural sector's energy needs. The Group strongly urged increased activity, at both the national and international levels, in the areas of both by intensifying current efforts and by creating new programmes where needed.

INDUSTRIAL ENERGY INCLUDING TRANSPORT AND ALLIED SECTORS

The Group on Industrial Energy noted that the major question is to know which of the NRSE will play a significant role in industrial production. The answer depends mainly on the future energy requirements of the developing countries. If the objectives of the Lima Declaration are met, the developing countries will be using 130 million barrels of oil a day equivalent (mboe/d), compared to their 1980 use of 34 mboe/d. Of this, 60 mboe/d will be used for industry, transportation, and related sectors, compared with 16 mboe/d in 1980. The Group noted that among these sources, hydropower and biomass are the ones likely to make the most significant contributions, both in quantitative and in qualitative terms.

Energy is vital for industry, and industrial growth is crucial to the continued development of most developing countries. This industrial growth cannot take place at the pace nor attain the targets envisioned by developing countries to the year 2000 unless the pattern of energy utilization alters and the development of NRSE takes place rapidly and as soon as possible. The development and utilization of these sources is of greater importance to developing countries not alone because they possess the greater unexploited resource potential but also because industrial growth is more crucial to their welfare than to the industrialized countries. Similarly, industry is vital for energy development. Industry in each country must, at the sectoral level and/or at the level of the enterprise, intervene and participate in the upgrading, refining, or transformation of certain NRSE to more conveniently usable forms for use by industry as heat energy. Industry also will have to undertake R and D, equipment and process design, and pilot plant experimentation prior to manufacturing equipment and facilities for utilizing these sources or converting them to suitable products for industrial transport, commercial, and residential use.

Implementation of national strategies for developing and using NRSE will require the formulation of specific programmes projects, and policies, particularly in the areas of planning and management. Among these are detailed planning of the national energy requirements; regional co-operation and development of energy programmes; international and regional co-operation; the management of decentralized system adaptation and exchange of technologies; actions in the field of educational training and information; and institutional arrangements.

Among the Group's recommendations it was indicated that efforts must be made to strengthen and broaden international technical assistance to governments of developing countries with due attention to NRSE for their national energy assessments which are a prerequisite for their formation of national energy strategies, plans, and programmes. The Group also recommended that international financing institutions provide highly concessional financial assistance and risk capital for the development of pioneer experimentation and commercialization of specific NRSE in order to accelerate utilization by all developing countries. Particular emphasis was placed on hydroelectric power, and it was urged that a master plan be created for the development of hydroelectric resources in the developing countries. The Group recommended the establishment of an international task force to study the development of biotechnology for industrial and transport applications. In addition, the UN system, especially UNIDO, should develop their services of industrial information and technology to small and medium size enterprises in the field of NRSE and industry since the development of these resources in developing countries would need appropriate supplies of specific investment and industrial information for a large number of small and disposed users. Finally, a UN body should be charged with monitoring the problems associated with the use and development of NRSE.

(Based on summaries prepared by Paul Martin and John Sheehan)

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of the solution: the selection of species suitable for deliberate cultivation as firewood crops in developing countries. Primary emphasis is placed on species suitable for growing firewood for individual family needs. However, species suited to plantation cultivation for fueling small industrial factories, electric generators, and crop dryers are also considered. Most of the plants are little known in traditional forest production. Some are woody shrubs rather than forest trees, but even these may meet many requirements for small-scale village use. Particular attention was paid to multi-purpose plants that have uses in addition to providing fuel, plants that adapt well to different sites and require little care, plants for problem environments and plants not consumed by goats and wildlife. Special consideration was given to nitrogen-fixing ability, rapid growth, ability to coppice, ability to produce wood of high calorific value that burns without sparks or toxic smoke and ability to grow successfully in a wide range of environments. After an introduction on wood as fuel, more than 60 fuelwood species for humid tropical, tropical highland and arid and semi-arid regions are presented. The data on existing plants cover their major attributes, description, distribution, use as fuelwood, yield, other uses, environmental requirements, establishment, pest and diseases and limitations. Appendices include technologies for improving the efficiency of fuelwood use, case studies from Ethiopia and the Republic of Korea and a master list of firewood species. More than 300 refs.

252/81 CHEMICALS FROM BIOMASS - THE U.S. PROSPECTS FOR THE TURN OF THE CENTURY. M.N. Sarbolouki and J. Moacanin (Energy and Materials Research Section, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91103 (USA)). Solar Energy, vol. 25, p. 303-15 (1980).

Historically, chemicals from biomass have been and are expected to be economical in three major areas: byproducts, specialty items and polymers. Assessments of producing major chemicals from biomass in a processing plant based on the available conversion techniques indicate that they are not economically attractive, with the possible exception of conversion to ammonia and ethanol. The deterrents are the heavy capital investments, dependability of raw-material supply and transportation costs for large plants, lack of operation experience, inadaptability to market variations, and competition from petroleum and coal. More importantly, it is also shown that even if chemicals from biomass were economical today, the resultant savings in petroleum would be far less than those achieved through other options available for the utilization of biomass as fuel and structural material. Thus, it is concluded that near-term research and development must be toward improved conversion processes, recovery of valuable products from waste streams at existing plants, more efficient use of biomass for energy and more efficient production of superior material products. 27 refs.

253/81 GROWING ENERGY: LAND FOR BIOMASS FARMS. AGRICULTURAL ECONOMIC REPORT (FINAL). K.A. Zeimetz (Natural Resource Economics Division, Economics, Statistics, and Cooperatives Service, Washington, DC (USA)). PB-296650 (June 1979) 41p. NTIS. US$8.50.

Biomass crops grown for energy conversion require high-quality land to maximize energy gain and minimize environmental hazards. The shortage of such land may hinder development of energy farms. Most of the 760 million acres of class I-IV rural land of sufficient quality to support biomass production would need considerable conservation measures to overcome inherent development problems. Furthermore, alternative sources of food and fiber production would need to be found if the land were diverted to energy farms.

254/81 WHICH ALCOHOL FUEL FOR BRASIL, METHANOL OR ETHANOL? A.V. Carvalho, Jr., V. Yang and S.C. Trindade (Centro de Tecnologia Promon - C-P, Rio de Janeiro 22210 (Brazil)). P. 295-300 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, Washington, DC, USA (1979).

This paper describes the present status of the various programmes in Brazil devoted to the production and utilization of alcohol-based fuels, namely methanol and ethanol. The processes used for the production of each of these fuels are presented. 13 refs.

255/81 SOLAR BIOCONVERSION SYSTEMS BASED ON ALGAL GLYCEROL PRODUCTION. L.A. Williams, E.L. Foo, A.S. Foo, I. Kuehn and C.G. Hedén (Karolinska Institute, Stockholm (Sweden)). P. 115-30 of Proceedings of the Eighth Biotechnology and Bioengineering Symposium, 1978.

The capture of solar energy in the form of glycerol-rich cell mass of the halophilic algae Dunaliella offers some unique possibilities for the production of food, fuels, and chemicals. Especially interesting is the possibility for an all-microbial route to liquid fuels such as ethanol starting with CO_2, although the most immediate applications will probably be the production of glycerol itself.

256/81 CONTINUOUS STEADY STATE BIOSYNTHESIS OF CELLULASE BY T. Viride QM9414 UNDER CONTROLLED pH. V. Sahai and T.K. Ghose (Indian Institute of Technology, New Delhi (India)). P. 269-80 of Bioconversion of Cellulosic Substances into Energy Chemicals and Microbial Protein (Proceedings of the Symposium on Bioconversion of

Cellulosic Substances into Energy, Chemicals and Protein, held New Delhi, India, Feb. 1977). T.K. Ghose (ed.), Indian Institute of Technology, New Delhi, India (1978).

Trichoderma viride QM 9414 was grown in a single-stage continuous-culture system to produce a cellulase enzyme using glucose and cellulose as a carbon source. Experiments were carried out in a 5-liter fermenter at 28 °C, K_L at 250 h^{-1} and pH 5.0 over a range of dilution rates from 0.012 to 0.028 h^{-1} using cellulose as a carbon source. The steady-state values of substrate, cell mass, soluble protein and cellulase activity were determined. The estimated values of maximum specific-growth rate, saturation constant, maximum-yield coefficient and maintenance coefficient of the organism were found to be 0.031 h^{-1}, 0.11 g/l, 0.45 and 0.031 h^{-1} respectively. The cellulase activities could not be detected in cultures grown on glucose. The maximum enzyme productivity of about 21.2×10^{-3} IU/ml/h was observed when the culture grew on cellulose between dilution rates of 0.02 to 0.023 h^{-1}. The ratio of enzyme activity to the total soluble protein was more or less constant at a value of 0.82. The specific-protein synthesis rate was linearly related to the specific-growth rate.

257/81 PRODUCTION OF LIQUID FUELS FROM PLANTS - UTILIZATION OF BIOMASS (SHOKUBUTSU KARANO EKITAI NENRYŌ SEISAN - BAIOMASU NO RIYŌ). Ito T. (Idemitsu Kōsan Co. (Japan)). Idemitsu Sekiyu Gijutsu (Idemitsu Petroleum Journal), vol. 22, no. 1, p. 78-81 (1979). In Japanese.

Nature's carbon cycle and the utilization of biomass are outlined, and the problems concerning the production of alcohol from biomass are described in detail. This production process requires much energy, and actually exceeds that obtained from the alcohol itself. The requirements of immense areas of land for plantations and a vast number of tanks to implement the fermentation on a practical scale, are some of the problems involved in this process. To facilitate the practical application of this technology, a combination of this process with other energy industries must be studied. 3 refs.

258/81 A NOVEL KIND OF FUEL AND FERTILIZER. S.D. Ghatnekar (C.C. Shroff Research Institute, Excel Estate, Goregaon (W), Bombay 400 062 (India)). Khadigramodyog, p. 209-11 (Dec. 1980).

The increasing population of India and its need for energy are putting great stress on the ecosystem. Deforestation is increasing at a rapid rate and is threatening to destroy vast quantities of top soil that have taken thousands of years to evolve. To help eliminate this problem, it is suggested that waste biomass (particularly water hyacinth and African payal) be used to make dried cakes by a 20-40 day fermentation process. The use of these waste weeds will also help solve a major problem which they are causing for many canals, rivers and paddies.

C2. BIOGAS PRODUCTION AND UTILIZATION

259/81 GUIDEBOOK ON BIOGAS DEVELOPMENT. United Nations Economic and Social Commission for Asia and the Pacific, Bangkok (Thailand)). Energy Resources Development Series, no. 21. ST/ESCAP-96. United Nations, New York, NY, USA (1980). US$11.00.

This guidebook covers the practical aspects of small-scale biogas development suitable for use in rural areas in developing countries, especially those of the ESCAP region. It is intended that all aspects of biogas are covered so that someone with no knowledge of the subject can, with confidence, design, build, operate and maintain a biogas plant. Information on biogas technology in China is also included. Chapters cover: the biogas process; factors effecting gas-plant design and operation; the classification and design principles of plants; design, size and site selection; the construction of digesters; gas holders and pipes; household gas appliances and their use; starting and operating a biogas digester; servicing and safety; improving gas-plant performance; commercial uses of biogas; the effluent and its uses, biogas-plant development programmes; community plants; and economics. In the annexes, designs for biogas plants of the fixed-dome, bag and floating gas-holder type are presented. 9 refs.

260/81 METHANE GENERATION BY ANAEROBIC FERMENTATION: AN ANNOTATED BIBLIOGRAPHY. C. Freeman and L. Pyle (Intermediate Technology Development Group, London (UK)). Intermediate Technology Development Group, London, UK. 71p.

This bibliography is for those who are directly involved or interested in building, designing, or improving methane generators in developing countries. It includes the basic and relevant material required to enable those working in this field to decide on the viability of gas production and to help them learn from other people's experience.

261/81 DESIGN ANALYSIS OF SMALL-SCALE ANAEROBIC DIGESTERS IN INDIA. C. Chiranjivi (Chemical Engineering Department, Indhra University, Waltair (India)). P. 449-64 of Proceedings of the Symposium on Energy from Biomass and Wastes (held Washington, DC, USA, Aug. 1978). 1978.

Five digester designs are described. These include: a batch-process digester which produces up to 3.4 m^3 of gas per day for a 30 to 40-day period when initially supplied with 4 tonnes of manure; a continuous biogas plant which is supplied with 50 kg of dung per day, and produces up to 2.8 m^3 of gas per day; a two-state digester built of reinforced concrete which produces between 28 and 85 m^3 of gas per day on the manure from 50 cows; a multi-digester plant producing up to 71 m^3 of gas per day; and the Indian Agricultural Research Institute design which produces some 2.5 m^3 of gas per day using 45 kg of fresh dung per day and an initial supply of 910 kg of dung. 5 refs.

262/81 A DOME-BIOGAS PLANT WITH SEPARATE GAS HOLDER - A SYSTEM UNDER EXPERIMENT IN CHINA. B. Stephan (Technical College, Bremerhaven (Fed. Rep. of Germany)). Biogas Forum, no. 3, p. 4-7 (1980).

This short article briefly describes two types of Chinese biogas digesters: the integrated gas-dome type and the separate gas-holder type. The advantages and disadvantages of each system are outlined. Basically, the integrated gas-dome type is relatively inexpensive and compact but has problems with leakage and unstable pressure, whereas the separate gas-holder type is larger and more expensive but is free of the other's defects and is more efficient.

263/81 RECOVERY OF ENERGY BY METHANE FERMENTATION. Ono H. (Sumitomo Heavy Industries, Tokyo (Japan)). Sumitomo Jūkikai Gihō (Sumitomo Heavy Industries Technical Journal) vol. 26, no. 78, p. 94-7 (1978). In Japanese.

This review, with 8 references, discusses methane as an energy source, optimal conditions and cellulosic wastes for methane fermentation, and feasibility of the industrialization of fermentation by using industrial and agricultural-waste materials in combination with organic-fertilizer production.

264/81 DESIGN AND OPERATION OF A FARM-SIZE ANAEROBIC DIGESTER FOR SWINE. J.R. Fischer, N.F. Meador, D.M. Sievers, C.D. Fulhage and E.L. Iannotti. Paper presented at the American Society of Agricultural Engineers Annual Meeting (held Raleigh, NC, USA, 26 June 1977). American Society of Agricultural Engineers, St. Joseph, MI, USA (1977) 27p.

A 140-m^3 digester for swine waste has been designed, constructed and is successfully operating. The average loading rate over the 27 weeks has been 2.1 g VS/l/d and produced the following chemical conditions in the digester: COD-8200 mg/l, VS-6000 mg/l, pH-6.8, alkalinity-2100 mg/l, NH_3-N-380 mg/l. The bacterial population was 5.6 x 10^7 organisms/ml.

265/81 BIOGAS FOR JAVANESE VILLAGES: THE PRODUCTS OF DIGESTION. J. Steward and B. Richmond (World Vision of Asia, P.O. Box 101, Malang, East Java (Indonesia)). Appropriate Technology, vol. 7, no. 3, p. 14-6 (1980).

The techniques and experiences with various biogas-generation and utilization devices in a Javanese village are given. Information on generation includes mostly data on mixing, temperature and time factors. Various simple and inexpensive cooking burners and lamps are also discussed. The article concludes with suggestions for the use of the biogas digester effluent as fertilizer, soil conditioner, and water hyacinth and algae substrates.

D. WIND ENERGY

266/81 PERFORMANCE OF A LOW COST CROSS-WIND-AXIS SAIL-WIND TURBINE. G. Ahmadi (Department of Mechanical Engineering, University of Shiraz, Shiraz (Iran)). Energy, vol. 5, p. 1045-52 (1980).

The performance of a model cross-wind-axis sail rotor is investigated. Several different types of sail blades are employed and the effects of wind velocity, blade pitch angles, and external load on the efficiency of the rotor are studied. 21 refs.

267/81 HOW ONE BUILDS WINDMILLS. CALCULATION, CONSTRUCTION AND OPERATION (WIE MAN WINDRÄDER BAUT. BERECHNUNG, KONSTRUKTION UND AUSFÜHRUNG). F. von König. Ud. Pfriemer Verlag GmbH, München, Fed. Rep. of Germany (1978) 190p. In German.

After some reflections about the amount of energy in air streams, the following problems are discussed: wind power on windmill blades, size and shape of the blades; an American wind-turbine project; modern high-speed rotors; a wind turbine of medium rotational speed; performance of a La Tour blade; a wind wheel with triangular sails and a vertical-axle turbine. Work-shop assembly information for wind turbines are also specified.

268/81 DESIGN AND PERFORMANCE OF BICYCLE WIND TURBINE ROTORS. W.M. Mansour and M.H. Hirata (Department of Chemical Engineering, Federal University of Rio de Janeiro, Rio de Janeiro (Brazil)). P. 308-11 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, 5 Aug. 1979). American Chemical Society, Washington, DC, USA (1979).

A new design is presented for wind-turbine rotors of the bicycle wheel type. The new system is evaluated aerodynamically and its constraints are identified on the basis of experimental results carried out in a wind tunnel. 2 refs.

269/81 DESALTING BY ELECTRODIALYSIS USING WIND POWER. W.P. Harkare, K.P. Govindan, V.H. Vaidya, K.M. Majeethia and H.M. Gohil (Central Salt and Marine Chemicals Research Institute, Bhavnagar (India)). P. 448-53 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Desalination of water by electrodialysis is an established practice, especially for brackish water. Electrical energy is the driving force and the energy requirement for this process is of a low order. In the present investigation, an attempt has been made to use wind power for the generation of electricity to power an electrodialysis unit without an energy-storage system. The potential of this process for the desalination of brackish water for drinking purposes in small communities and isolated areas where electric-power supply is not available is discussed. The viability and economics of the process for use in small communities are outlined. Comparison of desalination by electrodialysis using solar power and wind power as sources of electrical energy is presented.

270/81 IRRIGATION FOR VERY SMALL FARMERS: APPROPRIATE TECHNOLOGY OR APPROPRIATE ORGANISATION? P.B. Ghate. Economics and Political Weekly, vol. XV, no. 52, Review of Agriculture, p. A-161-A-172 (Dec. 1980).

Under the Integrated Rural Development Programme of India, small and marginal farmers are offered subsidies of 25 and 33%, respectively, of the capital cost of a ground-water structure. However, in view of the small and uneconomic size of irrigated land held by such farmers, the benefits of the programme can accrue to them only if the technologies of raising ground-water resources can be shared. Equally important are appropriate organizational solutions to the many problems that will invariably arise in the implementation of such programmes. This paper considers the results of ongoing action research in this field in Ghazipur district, eastern Uttar Pradesh. It first considers two examples of 'hardware' solutions: the twin-plunger irrigation hand-pump; and the irrigation windmill currently being developed in Ghazipur by a voluntary organization. The paper concludes with a consideration of two organizational or 'software' solutions: mobile pumpsets shared between a group of farmers; and state, community or 'agency' tubewells.

271/81 WIND POWER. VOLUME 1, 1970-1977 AND VOLUME 2, 1978-APRIL 1979 (CITATIONS FROM THE ENGINEERING INDEX DATA BASE). A.S. Hundemann (National Technical Information Service, Springfield, VA (USA)). NTIS/PS-79-0535 and NTIS/PS-79-0536 (June 1979) 225p and 131p. NTIS. US$65.00.

Windmill and wind-power feasibility, use, and engineering are discussed in these citations of worldwide research. Abstracts primarily cover the use of wind power for electric-power generation and wind-turbine design and performance. General studies dealing with the use of wind power in developing countries and comparative analyses of wind power and alternative energy sources are included, as are studies on energy-storage systems. This updated bibliography contains 344 abstracts, 113 of which are new entires to the previous edition.

272/81 CONVERSION AND STORAGE OF WIND ENERGY AS NITRATE FERTILIZER. M. Dubey. P. 83-6 of Proceedings of the Energy Research and Development Administration Contractors' Review Meeting on Chemical Energy Storage and Hydrogen Energy Systems (from the Meeting for the Contractors in the Energy Research and Development Administration Hydrogen Energy Program, held Airlie House, VA, USA, 8 Nov. 1976). 1976.

This paper describe a unique method for storing wind energy, one which converts it to a useful energy product, nitrate fertilizer. In this concept, the wind energy is captured by a wind turbine, combined with water and air, converted to anhydrous ammonia, and then to an ammonium nitrate solution. These high-energy fertilizer compounds are, in a sense, the final storage medium for the wind energy. The research study is investigating technical and economic feasibility for the concept, identifying the technical obstacles requiring solution, and defining a programme for demonstration.

E. ENERGY STORAGE

273/81 ZEOLITES: CLAY SILICATES THAT OFFER HOPE OF COMPACT SOLAR STORAGE. J. Szostak. Canadian Renewable Energy News, vol. 2, no. 7 (Sept. 1979) 25p.

The use of zeolites to store solar energy as a chemical potential could prove to be more effective than using rocks or water. The search for a simple, non-corrosive system able to activate at temperatures of 300 °C or lower, and to store heat indefinitely, identified crystalline zeolite, a clay silicate, as having the most promise of a group of four absorbent classes. Zeolite is more expensive as well as more efficient, but the simple technology possible with a non-toxic, non-explosive agent that needs no insulation offsets some of the cost differential. Solar heating combined with zeolite storage could make solar energy systems economically viable by eliminating the need for backup systems.

274/81 THERMAL ENERGY STORAGE USING SATURATED SALT SOLUTIONS. M.A. Bell and I.E. Smith (School of Mechanical Engineering, Cranfield Institute of Technology, Cranfield, Bedfordshire MK43 0AL (UK)). Energy, vol. 5, p. 1085-90 (1980).

In order to reduce the volume required to store low-grade thermal energy in water, various systems using phase change materials (PCMs) have been proposed. However, in order to overcome the poor heat-transfer characteristics associated with the solidification of the PCM on heat-transfer surfaces, large surface areas need to be provided. This is often achieved by encapsulation in either large or small containers, which has the effect of increasing the cost and reducing the effective-energy density. Furthermore, PCMs can only accept and release heat at a particular temperature. In an attempt to overcome these limitations, thermal-energy storage using saturated-salt solutions has been examined. The energy density for a number of promising salts has been calculated and confirmed by experiment. Energy density increases of up to 4 times that of water are possible, depending on the salt used and the temperature swing permitted. The deposition of crystals from the solution on heat-exchanger surfaces has been overcome by the use of a novel self-cleaning technique. 7 refs.

275/81 HEAT STORAGE IN A SOLAR HEATING SYSTEM USING SALT HYDRATES. S. Furbo and S. Svendsen (Thermal Insulation Laboratory, Denmarks Tekniske Hoejskole, Lyngby (Denmark)). EUR-6646 (Pt. 1) (Oct. 1977) 100p. NTIS. US$10.50.

A new method, by means of which a salt-water mixture consisting of an incongruently melting salt hydrate with additional water works stably as a heat-storage material, has been developed. The storage capacity of different promising salt-water mixtures was calculated and measured in a heat-storage system using oil as the heat-transfer fluid. The storage system (0.2 m^3) seemed to work as planned. In order to show that a heat-storage system using a salt-water mixture as the heat-storage material will work as planned in a solar-heating system during a long period of time, different improvements concerning the performance of the storage system must be carried out. Also a full-scale heat-storage system must be built and tested under realistic conditions for a long period of time.

276/81 LONG-TERM STORAGE OF SOLAR ENERGY IN NATIVE ROCK. M. Riaz (University of Minnesota, Minneapolis, MN (USA)). Vol. 1, p. 474-9 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

Long-term storage (annual or seasonal) of solar-collected thermal energy in native rock or sandstone appears to be both technically feasible and economically attractive. In this storage concept, a large bed of crushed or naturally formed porous rock is heated by hot air flowing from a central manifold to two cold manifolds; on discharge, the flow is reversed and cold air, introduced at the top and bottom manifolds, is heated in passing through the porous media so that hot air can be harvested at the central manifold. The paper discusses some of the basic factors and constraints which govern the performance of such earth thermal-storage units and evaluates several possible construction methods of interest from which a storage-cost assessment can be made. 6 refs.

277/81 STORE ENERGY IN GROUND. B. Givoni (Desert Research Institute, Ben-Gurion University, Beer Sheva (Israel)). Chemtech, vol. 9, p. 384-90 (June 1979).

Energy, particularly solar energy, is not always available when it is needed. Thus, as energy supplies dwindle there is an accelerating effort to understand the means of storing energy. In this article various configurations for storing energy in the ground are considered. 8 refs.

278/81 SENSIBLE HEAT STORAGE FOR SOLAR ENERGY APPLICATIONS. R.K. Romak and P.P. Von Hatten (University of Western Ontario, London, (Canada)). Vol. 2, p. 1.3.3.1-1.3.3.8 of Renewable Alternatives (Proceedings of the Fourth Annual Conference of the Solar Energy Society of Canada, held London, Canada, 20 Aug. 1978). Solar Energy Society of Canada, Winnipeg, Manitoba, Canada (1978).

This paper studies a group of eight selected materials. These include three sizes of rocks, clay balls, broken drainage tile, brick rubble, iron oxide pellets, and blast-furnace slag. Initially the materials' properties were analysed. This was based on size, shape, density, and thermal characteristics. Each material was then tested. A model heat-storage unit was constructed to perform heating, cooling and pressure-drop tests. These results, combined with costs, produced the material most suitable. It was found that the ideal material consists of small particles, has high density and heat capacity and packs with a small void ratio. The 2-cm stone was selected as most suitable.

279/81 EXPERIMENTAL STUDY OF LATENT HEAT STORAGE FOR HOUSES. L. Bourdeau, A. Jaffrin and A. Moisan (Observatoire de Nice, Nice (France)).

P. 373-404 of Proceedings of the Second International Solar Forum (held Hamburg, Fed. Rep. of Germany, 12 July 1978). Deutsche Gesellschaft für Sonnenenergie eV, München, Fed. Rep. of Germany. In French.

Three types of walls with latent heat, which contain a CaCl-based substance, have been developed to sponsor the collecting, storing and distribution of solar energy in flats. Measurements which have been taken under laboratory and actual conditions have permitted the calculation of the optimal thermal achievements.

280/81 PASSIVE ENERGY STORAGE IN GREENHOUSES. G.L. Morrison (Department of Mechanical and Industrial Engineering, University of New South Wales, Sydney (Australia)). Solar Energy, vol. 25, p. 365-72 (1980).

A passive-energy collection and storage system for greenhouses, based on the collection of energy from the greenhouse atmosphere and storage in the ground, is investigated. A thermosyphon circulation system to transfer the energy from the moist air in the greenhouse to the ground is analysed, and preliminary experiments in a small greenhouse are reported. 6 refs.

F. SOCIO-ECONOMIC ASPECTS

281/81 EROSION, DEFORESTATION AND THE LOSS OF PRODUCTIVITY. C.A. Pryor (Rockefeller Foundation, New York, NY (USA)). P. 78-87 of Caribbean Consultation on Energy and Agriculture (Consulta del Caribe Sobre Energía y Agricultura). Instituto Superior de Agricultura, Santiago, Chile (1980).

Agricultural productivity and energy supply and demand are uniquely related to environmental quality. Environmental media (soils, air and water), may be both a producer's good as well as a consumer's good. Debate about the environment has been dominated by concern over the latter (and a concern over the loss of amenities), rather than over the former. However, for the developing world the former case, as exemplified by erosion, is by far the most important since it directly affects agricultural productivity. Energy is consumed directly in the agricultural sector, as well as by other segments of the rural economy. It also can be produced from agriculture and from resources (such as dung) equally as important to agriculture as to the energy sector. These complex linkages all affect or are affected by the environment in unique ways. In the Caribbean the relationship between firewood demand and shifting cultivation in the marginally productive hill lands is critical, not necessarily in its effect on the importation of fossil fuels, but on environmental deterioration and the resultant damage to agricultural productivity. In conclusion, it will be important that all future decisions concerning new energy sources such as biomass are analysed in terms of their effect on agricultural productivity through environmental deterioration.

La productividad agrícola y la oferta y demanda de energía están estrechamente relacionadas con la calidad ambiental. El medio ambiente (suelos, aire y agua), puede ser tanto un bien de producción como de consumo. El debate sobre el medio ambiente se ha centrado en este último aspecto (y en la preocupación por la pérdida de las amenidades) más que en el primero. Sin embargo, para los países en desarrollo el caso anterior es mucho más importante (la erosión, por ejemplo), porque afecta directamente la productividad agrícola. La energía es consumida directamente en el sector agrícola, o en otros segmentos del sector rural. También puede ser producida a partir de la agricultura, y de otros recursos (como el estiércol), importantes no sólo para la agricultura sino también para el sector energético. Todas estas articulaciones afectan y son afectadas por el medio ambiente en muchas formas. En el Caribe la relación entre demanda de leña y la agricultura migratoria en las tierras montañosas marginales es crítica, no necesariamente por su efecto sobre las importaciones de combustibles fósiles, sino por el deterioro ambiental y la consiguiente pérdida de productividad agrícola. En conclusión, es importante que todas las decisiones futuras sobre nuevas fuentes energéticas, como la biomasa, sean analizadas en términos de su efecto sobre la productividad agrícola por medio del deterioro ambiental.

282/81 ECONOMICS OF ADOPTING SOLAR ENERGY SYSTEMS FOR CROP IRRIGATION: COMMENT. J.W. Milon (University of Florida, Gainesville, FL (USA)). American Journal of Agricultural Economics, vol. 61, no. 3, p. 571-3 (Aug. 1979).

The author challenges the framework Katzman and Matlin presented earlier (American Journal of Agricultural Economics, vol. 60, p. 648-54 (1978)) for determining the viability of photovoltaic investments on the grounds that no distinction was drawn between social and private benefits. Katzman and Matlin respond that their purpose was flexible methodology for evaluating viable solar technologies in on-site irrigation and is not intended to handle the complicated social and private benefits of conventional irrigation systems. 6 refs.

283/81 PROSPECTS OF POWER GENERATION FROM SOLAR PLANTS IN THE NORTHEAST OF BRAZIL. L.S. Cheema, C. Torres and P.C. Lobo. P. 581-90 of Solar Energy (Proceedings of UNESCO/WMO Solar Energy Symposium, held Geneva, Switzerland, 30 Aug. 1976). World Meteorological Organization (1977).

The prospects for the utilization of solar power plants in the northeast of Brazil are studied for small communities removed from the power grid. The number of units that would be economically feasible depends on the price of the plant per unit of installed capacity and the possibility of energy-storage and subsidiary functions (distillation, pumping, etc.) performed by the plant. Some solutions that may reduce the cost of the plant and price targets that appear to be viable in the near future are considered. It is believed that the most interesting applications for a solar power plant lie in the low-capacity range (up to 10 kW). This position derives from the fact that solar-power cost per unit installed capacity is practically independent of the unit size, whereas in conventional plants an economy of scale applies, i.e. the cost per unit installed capacity falls as the capacity of the plant increases. Based on the electricity power grid in the northeast of Brazil, the maximum demand is estimated for small solar power plants based on two different selling prices per unit of installed capacity. 8 refs.

284/81 ECONOMICS OF SOLAR FLASH EVAPORATION. Y.P. Gupta and D. Singh (Punjab Agricultural University, Ludhiana (India)). P. 248-52 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Capital investment and cost of distilled water for different plant capacities have been evaluated for solar stills and a solar flash-evaporation unit. The results show that solar flash evaporation is economically superior to conventional solar stills.

285/81 ECONOMIC COMPETITIVENESS OF WINDMILLS. E.E. Lapin (Aerospace Corp., Los Angeles, CA (USA)). Energy Conversion, vol. 16, no. 4, p. 213-20 (1977).

The conditions under which windmills become competitive with the generation of electric power from fossil fuels are examined. The influence of cost on construction, financing arrangements, and the future cost of fuels is shown. Energy-storage and network arrangements for mills are considered briefly, as are alternate uses for mills, e.g. the utilization of mill output directly for heating or for the production of a fuel.

SELECTED ARTICLE

This article was prepared specifically for publication in ASSET.

NON-IMAGING CONCENTRATORS FOR SOLAR THERMAL ENERGY*

by

R. Winston and J. O'Gallagher
Enrico Fermi Institute, University of Chicago
5630 Ellis Avenue, Chicago, IL, 60637, USA

ABSTRACT

Compound parabolic concentrators (CPCs) permit the use of low to moderate levels of concentration for solar thermal collectors without the requirement of diurnal tracking. When used in conjunction with evacuated absorbers with selective surfaces a fully stationary CPC (designs with concentrations 1.1X-1.4X are now commercially available) has a typical efficiency of about 40% at 150 C° above ambient with available conventional materials. An experimental higher concentration 5X CPC requiring approximately 12 tilt adjustments annually, when used with a similar available evacuated absorber, has been built having a measured efficiency of 60% at 200 C° above ambient and is capable of efficiencies near 50% at 300 °C. With such thermally efficient absorbers, higher concentrations are neither necessary nor desirable. The temperature capabilities for CPCs with non-evacuated absorbers are somewhat more limited. However, with proper design, taking care to reduce parasitic thermal losses through the reflectors, non-evacuated CPCs will outperform the best available flat-plate collectors at temperatures above about 50-70 °C.

1. INTRODUCTION

Since early 1974 a new family of optical concentrators referred to as "ideal" light collectors [1-3] has been under study at Argonne National Laboratory and the University of Chicago. These concentrators differ from those based on traditional focusing optics in that they are optimized for a wide angular field of view and attain the maximum possible concentration permitted by physical principles. Single stage reflecting troughs for solar energy collection designed according to these methods have come to be called compound parabolic concentrators or CPCs and are by now well known for their ability to achieve moderate levels of concentration without active tracking of the sun [4]. The profiles of commonly recommended CPC configurations [5-6] are shown in Fig. 1 and illustrate the wide angular acceptance possible. Reflecting troughs with these profiles achieve geometrical concentrations of $C = (\sin\theta_c)^{-1}$, directing all rays within $\pm\theta_c$ at the aperture to the absorber, be it a flat surface, fin, wedge or tube. Designs similar to that of Fig. 1 coupled to an evacuated tubular absorber with a selective coating have been developed to a high

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degree at Argonne National Laboratory [7] as totally stationary collectors. These serve as the basis for several collector models which are commercially available now or will be in the near term.

In recent years the research has centred around two objectives: a) the evaluation of design and construction methods for CPCs with non-evacuated absorbers and b) the development of advanced evacuated CPCs. This report summarizes briefly the highlights of this research. It was shown that non-evacuated CPCs, although clearly not classified as high-temperature collectors, have a measured performance which exceeds that for typical flat-plate collectors at temperatures above roughly 60 °C and should have economic advantages as well if properly constructed. As part of this prototype-development effort, a comprehensive set of design methods and test procedures for non-evacuated CPCs was developed.

Furthermore, it has been shown that for evacuated CPCs a substantial improvement in optical efficiency, both in initial value and its stability over a relatively long lifetime, can be achieved by integrating the concentrating reflecting surface into the vacuum enclosure itself by shaping the outer glass envelope to the desired profile [3]. In the next three sections the procedures for designing a non-evacuated CPC are reviewed, a field application is described and a summary of evacuated CPC potential is given.

2. NON-EVACUATED CPC FOR APPLICATIONS NEAR 100 °C

Two different non-evacuated CPC designs were assembled and evaluated as part of a development programme with two basic objectives. First, we wanted to examine the optical tolerances, angular acceptances, and collection properties of basic CPC designs including a high-concentration, narrow angular-acceptance design. Second, we wanted to study the thermal problems which are unique to low concentration, non-tracking non-evacuated collectors. The results of these studies have appeared in greater detail elsewhere [8] but the major features of these efforts are summarized here.

The design problems for non-evacuated CPC collectors are entirely different from those for CPCs with evacuated absorbers. The former are particularly vulnerable to high heat losses if one uses an improper design. The recommended design constraints, based on more than two years of non-evacuated collector development, are summarized below: 1) use of one of the "backless" or "wrap-around" designs such as the cusp for a tubular absorber or vertical-fin design of Fig. 1a or 1b respectively; 2) use of selective coatings on the absorber; 3) avoidance of the use of cavity absorbers since they are characterized by high heat losses; 4) minimization or elimination of heat loss via conduction through the reflectors (this can be accomplished by using reflectors whose thickness is negligible compared to the overall dimension (e.g., height, aperture) of the trough, such as metallized plastics or films or by thermally decoupling the absorber from the reflectors by a small gap maintained by insulating stand-offs) and 5) use of a CPC profile calculated for an imaginary absorber surface which is inside the actual absorber surface. A resulting oversize of the actual absorber size of 5-20% is recommended.

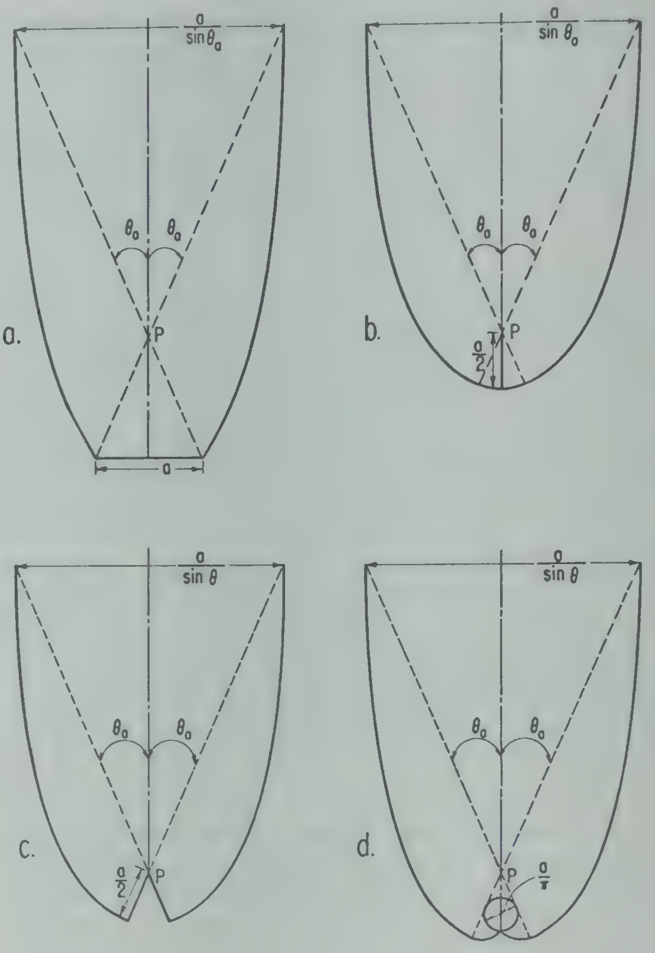

Fig. 1 Four basic CPC configurations

The two prototype non-evacuated CPC designs were constructed at the University of Chicago with different objectives in mind. An experimental CPC for a tubular absorber with a very narrow acceptance angle (±6.4°) was built to examine the behavior of a high-concentration, small acceptance-angle CPC. The absorber was a 7.9-mm diameter copper tube coated with black chrome. The profile of a cross section of the reflecting trough is shown in Fig. 2. The design

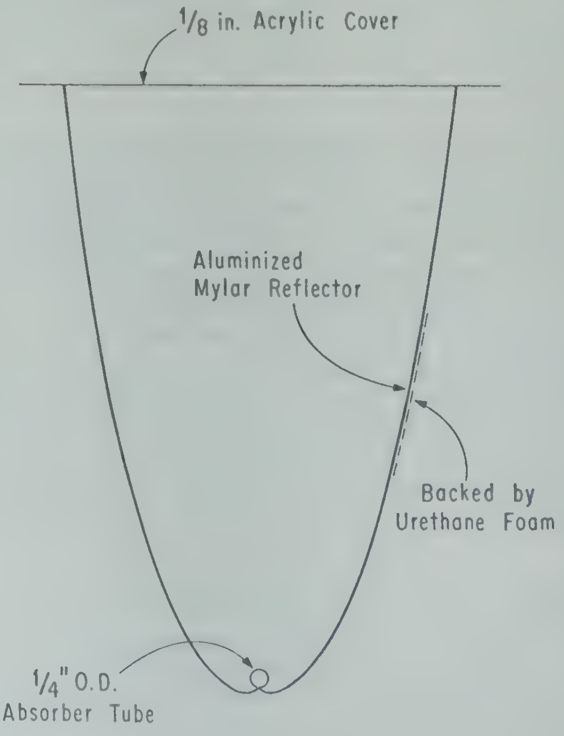

Fig. 2 Profile curve for non-evacuated 5.2X CPC

acceptance angle was ±6.4°, corresponding to an ideal concentration of 9.0X, but the profile was truncated to ∿1/3 of its full height resulting in a net concentration of 6.5X relative to its design absorber diameter of 6.4 mm and 5.2X relative to the actual oversized absorber used. The full collector consisted of 7 troughs each 1.8 m long with a total area of 1.67 m^2. Because of its small acceptance angle it require 24 yearly adjustments.

A prototype of 3X for a vertical-fin absorber was built to verify the production design for the experimental array of low-temperature CPC collectors at the Bread Springs School, an elementary school on the Navajo Indian Reservation near Gallup, New Mexico, USA. Since this collector was designed for heating applications only, the design acceptance angle was chosen to be ±18° to insure collection for at least 7 hours a day for the six-month period between the fall and spring equinoxes, with no tilt adjustments. For year-round collection, two tilt adjustments per year are required. The absorber is a fin (configuration of Fig. 1b) with a centre tube and each collector consists of a two-trough module with a cross section as shown in Fig. 3. Each module is 1.3 m^2 in net area and the troughs are 46 cm deep. Kinglux aluminium sheet 0.5-mm thick is used as the reflector ($\rho = 0.84$). The outer enclosure is a fiberglass epoxy tube with ASG water white glass as a cover.

We summarize in Fig. 4 the performance of these two collectors as determined from a series of measurements conducted over the past two years. The performance is characterized in the usual two-parameter form as

$$\eta_h\,(\Delta T/I_h) = \eta_{o,h} - U\,\Delta T/I_h \qquad (1)$$

where η_o is the "optical efficiency" (including heat-removal factor) and U the best-fit linear heat-loss coefficient. ΔT is the difference between average fluid temperature and ambient temperature, I_h is the total hemispherical insolation on the collector aperture and the subscript h refers to the efficiency relative to this quantity. A best fit to the data for the 5.2X yielded $\eta_{o,h} = 0.68 \pm 0.01$ and $U = 1.85 \pm 0.1$ W/m^2-°C. The thermal performance of the 3X fin CPC is characterized by $\eta_{o,h} = 0.58 \pm 0.02$ (hazy day) to $\eta_{o,h} = 0.63 \pm 0.02$ (clear day) and $U = 2.7 \pm 0.2$ W/m^2-°C. The angular-acceptance function of the 3X is shown in Fig. 5.

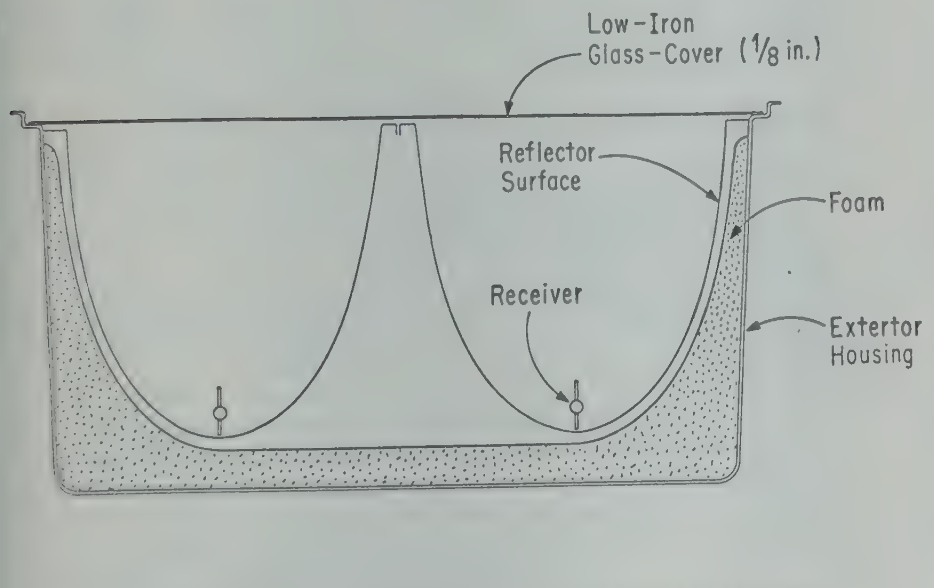

Fig. 3 Cross section of non-evacuated 3X fin CPC (prototype for Bread Springs project)

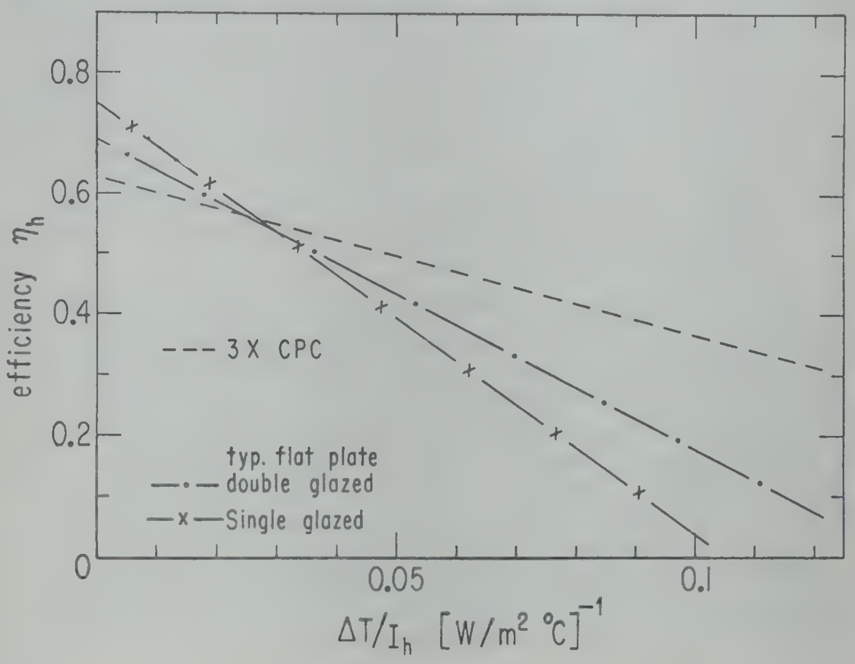

Fig. 4 Comparison of performance curves for non-evacuated CPCs and flat plate collectors

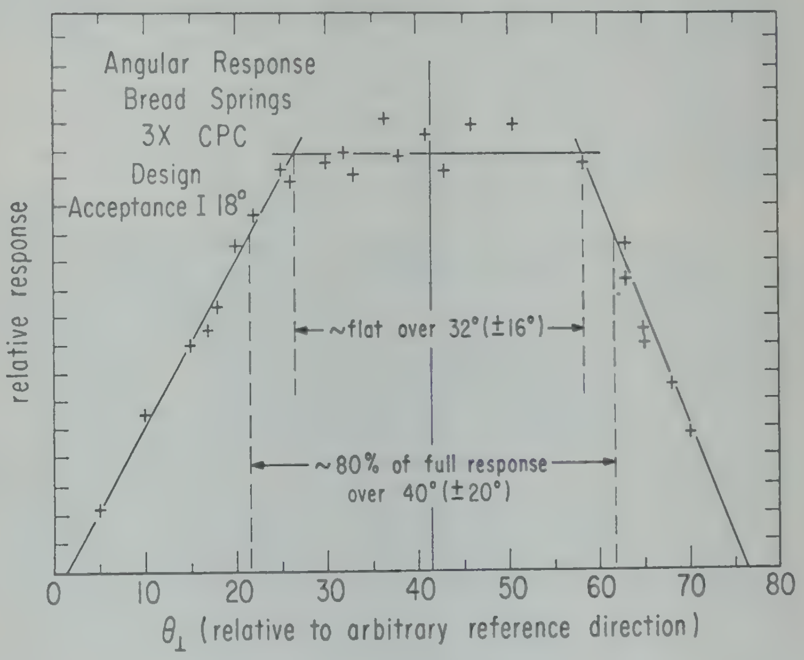

Fig. 5 Angular acceptance of 3X non-evacuated CPC

Despite lower optical efficiencies, the CPCs outperform typical flat-plate collectors above temperatures of as low as 10 C° above ambient (for the 5.2X) to about 35 C° above ambient (for the 3X). This is particularly important when it is recognized that the 3X should represent a relatively inexpensive collector design. While a detailed economic analysis cannot be based on the prototype construction methods used here and is beyond the scope of the present work, there are several unique features listed below which contribute to its low-cost potential.

a) The metal absorber fin of only 6.4-cm height effectively covers ∿30 cm of collector aperture. Thus the cost per unit aperture area of absorber plate is reduced by a factor of 6. (Both sides of the fin surface are utilized.)

b) No insulation (other than dead air space behind the reflectors) was used inside the actual production modules deployed in the field and no change was noted in the thermal-loss coefficient. Thus what is a significant cost component of most non-concentrating collector designs could be eliminated.

c) Inexpensive reflector materials (i.e. aluminized plastic reflectors or aluminized films on a thin substrate) could be used.

We reiterate our caution that care must be taken in the design of any non-evacuated CPC to avoid large parasitic losses through the reflector. Furthermore, to avoid sensitivity to misalignment and thermal deformation, particularly in the cases where high concentration ($\lesssim$ 4X) is combined with absorbers of small absolute dimensions ($\lesssim$ 1.25 cm), we recommend the use of absorbers oversized by about 20% with respect to the "theoretical" mathematical absorber surface for which the reflector-profile surface is generated and(b) the use of steel or other relatively strong material for the absorber tubes.

3. FIELD TEST OF 3X NON-EVACUATED CPC AT THE BREAD SPRINGS SCHOOL

The CPC collector array at the Bread Springs School consists of 56 of the two-trough 3X vertical-fin modules whose prototype was described above. There are 7 rows of 8 collectors each. Each trough has a net active length of 1.7 m and a width of 0.38 m yielding a net collecting area for each trough of 0.65 m^2 or 1.3 m^2 per module. Thus the entire collecting area of the 56 modules is 72.8 m^2.

In operation, water is pumped from an open drain tank through a heat exchanger in a large (8.2-kl) storage tank and from there directly to and through the collectors on the roof. The feed is split between the two halves (east and west) of the array. The two troughs in each module are fed in parallel with the four troughs in each half row connected in series. Each array half is mounted so that it slopes up towards the centre at a 4° angle and the collection pipe also slopes gradually up as it rises to the high point of the system where it spills back down through the 3° diameter open pipe to the drain tank. Upon pump shutoff the entire fluid capacity drains back down under gravity to the tank in the storage closet so that ordinary water without anti-freeze can be used as the heat-transfer fluid. To date performance has been quite satisfactory. Noontime efficiencies for the entire array are typically 45-50% at temperatures 50 C° above ambient, which is in quite good agreement with the single-module efficiencies shown in Fig. 4. The all-day efficiency on a cloudless day near winter solstice was 39% at an operating temperature 50-55 °C.

4. CPC WITH EVACUATED RECEIVERS

The heat losses associated with selective-absorber surfaces in vacuum are so low that the moderate levels of concentration associated with CPCs provide a dramatic improvement in thermal performance and achieve excellent efficiencies up to 300 °C. In fact, the gains associated with even higher concentration ratios are marginal at best and perhaps negligible when the added complication and expense of active tracking are considered.

The most important point to recognize is that the dramatic reduction in relative thermal losses produced by adding a 1.5X reflector or again in effectively tripling the concentration from 1.5X to 5X is not continued as one increases the concentration much beyond 5X. This is because at say $\sim$300 °C ($T/1 \cong 0.3$) the thermal losses for 5X are already so low that a further factor of 5 reduction corresponds to only a negligible fraction of the operating efficiency. Therefore it is neither necessary nor desirable to increase the concentration much beyond 5X when using an evacuated selective absorber at these temperatures. Thus the combination of CPCs up to $\sim$5X with these thermally efficient absorber tubes represents an alternative strategy for practical solar thermal collection up to power-generation temperatures with many unique advantages. At our laboratory a 5.5X CPC (requiring 12 tilt adjustments per year) coupled to a dewar-type evaculated absorber has achieved an operating efficiency of 58 ± 2% at 220 C° above ambient.

The most developed evacuated CPC design [5] is that optimized for totally stationary collection throughout the year, having an acceptance half angle $\theta_c = \pm 35°$ corresponding to a maximum "ideal" concentration of $\sim$1.8X. Commercial versions, truncated to net concentrations of $\sim$1.1X to 1.4X are now available with typical optical efficiencies in the range 50% to 58%. A 1.5X CPC operating at $\sim$150 °C has a heat-loss coefficient of $\sim$0.5 W/m^2-°C plus manifold losses yielding values ranging from 0.6-1.1 W/m^2-°C and over the 100-200 °C range has an efficiency of 30 to 50%. Thus solar thermal energy in an application range suitable for air conditioning and a wide variety of industrial processes is readily available from a completely stationary collector. Developmental efforts to reduce optical losses and produce a practical collector with an optical efficiency near 70% by integrating the reflector into the vacuum enclosure are in progress. Such collectors have the potential for thermal-electric power generation from a stationary collector.

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From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

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Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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ASSET 3/5

Abstracts of Selected Solar Energy Technology

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NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

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INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy

  B1 Radiation Measurement
  B2 Photovoltaic Conversion
  B3 Active Thermal Systems
  B4 Passive Thermal Systems

C. Bioconversion Energy

  C1 Biomass Production and Conversion
  C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

286/81 ENERGY FUTURES IN DEVELOPING COUNTRIES. S. Arungu-Olende (Centre for Natural Resources, Energy and Transport, United Nations, New York, NY (USA)). P. 14-45 of Energy and Environment in East Africa (Proceedings of the International Workshop on Energy Environment in East Africa, held Nairobi, Kenya, 7-10 May 1979). ERS-3-80 (March 1980). United Nations Environment Programme, Nairobi, Kenya.

The important role played by energy in a country's development is universally recognized. Consumption of energy has been growing steadily in the past three decades and the same general trend is expected in the future. This steady growth will have to be balanced against the availability of energy resources. In analysing energy requirements and prospects, a number of points energe. First, there is a wide disparity in energy consumption between the industrially developed and the industrially developing countries, and within the developing countries themselves. Second, with higher population-growth rates, faster rates of industrialization and a more pronounced shift from traditional sources of energy to commercial sources, the rate of consumption of commercial energy has been increasing faster in the developing countries, and will soon command a sizeable share of the world energy consumption. Third, energy problems of developing countries are closely tied to those of the industrialized countries. Policy decisions on energy made in the industrialized countries have a direct or indirect bearing on energy issues of the developing countries; and since 1973 major policy decisions taken by a group of developing countries have had a marked influence on the direction of development in energy matters in the industrialized countries. Energy issues are thus part of a global problem and must be seen and resolved as such. Fourth, as noted above, the world is or will soon be going through a critical time in energy resource development and utilization: the transition from a fossil-fuel energy base to another, as yet undermined, base. The impacts, including social, of such a transition are yet to be assessed. Of immediate importance to the developing countries, but less talked about, is a relative issue: forest resources are being used at a much faster rate than they are being replenished and, unless drastic steps are taken, the consequences will be more serious and much wider than the question of adequate availability of an energy resource. Fifth, at the present time, many developing countries are faced with a wide spectrum of problems that must be addressed and resolved if they are to attain and maintain a reasonable balance between energy requirements and supply in order to sustain sufficient levels of industrial and economic growth. The problems include inadequate financial resources, lack of skilled technical and managerial manpower, and inadequate policy guidelines for the formation of a viable energy resources-development strategy. Sixth, exploration, production and mining, processing, transportation and use of energy produce adverse impacts on the environment, the impact varying according to the energy sources. Seventh, increasing attention is being given to the development of new technologies for harnessing new and renewable sources of energy, including solar, wind, biomass, geothermal, ocean-thermal, tides and waves. However, there are major gaps in the understanding of these technologies, of their operation and of their applicability under varying conditions, especially those pertaining to the industrially developing countries. And lastly, an item that has received only casual attention in many developing countries: energy conservation and efficiency of use. In order to be effective, the question must be addressed and tackled in a systematic way as part of an overall energy development strategy.

287/81 ENERGY IN A FINITE WORLD - VOLUME I. PATHS TO A SUSTAINABLE FUTURE. International Institute for Applied Systems Analysis (Laxenburg (Austria)). Ballinger Publishing Co., Cambridge, MA, USA (1981) 225p. US$16.00.

This volume summarizes the findings of a study on the global energy system by the International Institute for Applied Systems Analysis. The volume begins with a warning that there is no easy fix to the energy problem and then describes the approach used in the study. Subsequent chapters cover fossil resources, nuclear energy, solar energy and renewable energy resources. Other chapters cover: constraints such as market penetration; climatic impacts and risks; the problem of balancing supply and demand; and the integration of data into a global system. It is concluded that (1) balancing energy supply and demand is difficult but could be achieved; (2) only radical changes in life styles could lead to a very low energy demand; (3) conservation measures implied in a low-energy scenario for the future are strong; (4) high-energy scenario projections require economic-growth rates that would be considered moderately satisfactory but would be difficult to supply; (5) the hard-soft controversy is essentially a political issue and not a technical one; (6) the demand for liquid fuels is a principal driving force of the energy problem; (7) the structure of secondary energy demand over the next 50 years will change at a very slow rate; (8) over the next 50 years under any circumstances, economic growth rates will be limited; (9) political, societal and institutional problems will probably make the situation more grim than has been described in the scenarios of the study; (10) fossil fuels will continue to be available but will become increasing unconventional and expensive; (11) renewable energy sources can contribute in an important, though limited, way to meet demand; (12) the oil-exporting nations will continue to dominate the oil market but an international coal market will develop as well; (13) coal liquefaction must be installed with a strategic view; (14) if nuclear energy is used primarily to supply the process heat for coal liquefaction, there will be enough coal to produce liquid fuel for 100 years or more; (15) if there is a nuclear moratorium, gas resources would be largely exhausted by the year of 2030; (16) while the growth of energy investments will be significant they will not be a large portion of the GDP in the industrialized regions; (17) the global impact of waste heat will probably not be a problem; (18) the carbon dioxide build-up caused by fuel combustion is probably the most severe climatic issue; (19) low-density energy-collection devices spread over large areas could have climatic impacts as well; (20) the debate on the issues of waste disposal and on the proliferation of nuclear weapons because of the civilian uses of nuclear power could limit the build-up of nuclear energy over the next 50 years; and (21) society has not yet developed adequate mechanisms for treating the risks associated with energy-supply technologies. 16 refs.

288/81 SAVING NEPAL'S DWINDLING FORESTS. F. Acker. New Scientist, vol. 89, no. 1248, p. 92-4 (1981).

This article describes the predicament of Nepal which depends on wood for its energy but is using its forests more than 7 times faster than it is replacing them. Examples are given of the use of water power and biogas from the waste of Nepal's 6 million cattle to provide alternatives to the use of fuelwood. It is noted that the country now possesses more than 200 biogas plants.

289/81 SOLAR ENERGY: ABOUT NEW ENERGIES. Université de Dakar (Dakar (Senegal)). PB-297866 (20 Jan. 1979) 156p. NTIS. US$13.50.

The uses of solar energy are extensively covered in this highly technical and thorough treatise. Geothermal and wave energy are briefly examined as possible renewable, universal and clean sources of energy. Physical, thermodynamic and quantum-chemical properties are analysed and applied to various transformations: (1) electrical transformations and industrial applications (photoelectric cell, photovoltaic cell, semiconductor); Se, Si, and Ge are examined as sources of photosensitive semiconductors; (2) transfer to chemical energy (photochemical preparation of chemicals, electrolyses of water using photosensitive semiconductors); photosynthesis is extensively treated as a source of both food and fuel (combustion, pyrolysis, aerobic and anaerobic fermentation). In the second part of the book, solar energy programmes in Zaire are discussed. These include projects to: measure the amount of solar energy received at 12 different stations; develop television transmission and reception; and pump and heat water. Future programmes for Zaire, Senegal, Niger, and the Ivory Coast are listed.

290/81 PROBLEMS AND OPPORTUNITIES FOR SOLAR ENERGY IN BIOMASS, PYROLYSIS, AND GASIFICATION. T. Reed (Solar Energy Research Institute, Golden, CO (USA)). SERI/TP-335-495 (1979). Solar Energy Research Institute, 1536 Cole Boulevard, Golden, CO. 80401, USA. 14p.

The need for a continuing supply of liquid and gaseous fuels dictates that the best and most efficient ways of converting renewable and solid fossil fuels to clean-burning liquid and gaseous fuels must be found. One resource that should be explored is the use of direct solar energy to supply process heat for converting biomass. It is concluded that the use of passive solar energy for drying crops and wood is already significant and that active solar drying, requiring temperatures below 200 °C, can easily become an important substitute for fossil fuels in drying. It was found that: pyrolysis of biomass typically requires less than 1.7 GJ/day tonne at a temperature of 500 °C and this could be potentially supplied by direct solar heating; fast pyrolysis requires modest heat inputs with high heat-transfer rates at temperatures over 900 °C (particularly suited to a focusing solar collector); and char gasification using steam or CO_2 requires large energy inputs of temperatures over 900 °C making it the least likely field of application of solar energy.

B. SOLAR ENERGY

291/81 SOLAR ENERGY R & D IN IRAN: THE APPROACH AND THE PHILOSOPHY. S. Vojdani and V.J. Woollam (University of Technology, Tehran (Iran)). Vol. 1, p. 106-17 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

The approach and the philosophy of the solar energy R & D programme in Iran are stressed. Solar energy is important to developing countries not only as an alternative energy source, but also as a challenging new field of basic research with interesting opportunities for technological development and international collaboration. 7 refs.

292/81 SOLAR ENERGY IN THEORY AND PRACTICE (SONNENENERGIE IN THEORIE UND PRAXIS). J.P. Winkler and P. Gygax. Müller, Karlsruhe, Fed. Rep. of Germany (1976) 2 vols, 209p. In German.

In this presentation of the basic principles of solar energy utilization, an attempt is made to give easily comprehensible information related to its practical application to domestic heating and hot-water supply. Volume I deals with the principles of effective architectural designs with regard to heat economy. The second volume is concerned with the components of a system for solar energy utilization and describes the most economical fields of application: water heating and swimming pools. The booklet concludes by pointing out some remarkable aspects concerning structural physics.

293/81 PHOTOVOLTAIC/THERMOELECTRIC REFRIGERATOR FOR MEDICINE STORAGE FOR DEVELOPING COUNTRIES. R.L. Field (Department of Mechanical Engineering, Texas A&M University, College Station, TX 77843 (USA)). Solar Energy, vol. 25, p. 445-7 (1980).

Small refrigerators for medicine storage are needed in remote parts of the world where electric power is not readily available. The thermo-electrically cooled refrigerator which operates on direct current is ideally suited for matching with an array of photovoltaic cells and an 18-VDC lead-acid or advanced-battery power system. In this paper, a design for a collapsible, portable, photovoltaic thermo-electric refrigerator is presented. The unit must be very rugged and operable by unskilled persons. The components of the system are commercially available. The paper includes estimates of the costs of the system. 6 refs.

294/81 DENDRITIC TUNGSTEN FOR SOLAR THERMAL CONVERSION. J.J. Cuomo, J.M. Woodall and T.H. DiStefano (IBM Thomas J. Watson Research Center, Yorktown Heights, NY (USA)). P. 133-8 of Proceedings of the American Electroplaters Society Coatings for Solar Collectors Symposium (held Atlanta, GA, USA, 9 Nov. 1976). American Electroplaters Society, Inc., Winter Park, FL, USA (1976).

Tungsten dendrites, formed normal to a surface, were found to efficiently absorb radiant energy over a broad spectral range and an absorption of 0.97 was found for wavelengths of 0.2 to 1.0 μm. The material was deposited by the hydrogen reduction of tungsten hexafluoride (WF_6) on substrates that were heated to 500 °C. Tungsten dendritic growth was independent of the crystalline state of the substrate for saphire, tungsten, molybdenum, stainless steel, quartz, carbon and silicon. An anti-reflection conformal coating of WO_3, produced by anodization of the dendrite surface, enhanced the absorptivity in selected regions of the spectrum, i.e., an absorptivity of 99.94% was found at a wavelength of 0.600 ± 0.10 μ. It was also shown that the average solar absorptivity of thin films of tungsten with a gray hillock surface was enhanced from 75 to 92% by anodization to a selected thickness.

295/81 NEW APPROACH TO LOW COST LARGE AREA SELECTIVE SURFACES FOR PHOTOTHERMAL CONVERSION. B.K. Gupta, F.K. Tiwari, O.P. Agnihotri and S.S. Mathur (Indian Institute of Technology, Delhi (India)). International Journal of Energy Research, vol. 3, p. 371-7 (1979).

In the presented study, selective black-paint coatings were prepared by coating reflective metal particles with a layer of selective black material. The coated particles were mixed in a binder and applied easily as a thin layer onto aluminium or galvanized-iron sheet. Three selective black materials, namely CuO, CuS and PbS+CuS were deposited on a zinc metal powder. The solar absorptance of the coatings ≅ 0.95 and the emittance ≅ 0.4. The thickness of the coatings was about 20 to 30 μm. The emissivity decreased as the thickness increased, while the solar absorptivity did not change appreciably. The improvement in the collector efficiency, which is the ratio of the temperature increase above the temperature of the standard panel above the ambient temperature, was estimated to be around 11%. This is potentially a low-cost process for large-scale application in solar photothermal conversion. 8 refs.

296/81 SPECTRAL SELECTIVE PROPERTIES OF BLACK CHROME AND NICKEL ELECTRODEPOSITED COATINGS FOR SOLAR ABSORBER. M.R. Rao, J. Balachandra and K. I. Vasu (Indian Institute of Science, Bangalore (India)). Vol. 2, p. 875-80 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1987). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

Electrodeposition methods for producing selective coatings of nickel and chromium were studied. The plating conditions for depositing black nickel or black chromium (from non-proprietary baths) on nickel-plated mild-steel and aluminium samples (3.81 x 3.302 cm) are being optimized for good coatings, the thicknesses of which are to be controlled to have a large-scale absorptance and a small thermal or IR emittance. Attempts to electrodeposit bright nickel or black chromium directly onto aluminium (without an intermediate coating of zinc) have not been successful, while electrodeless nickel plating on aluminium offers to avoid the intermediate zinc conversion coatings, which is to be obtained after a preliminary cleaning of the aluminium base, either by chemical or electrochemical process. The electrodeless coating contains phosphorous in the deposit, the phosphorus content depending on the operating conditions. Electrodeposition procedures are described and spectral-reflectance graphs are given for black nickel on mild steel, black chromium on mild steel, and black chromium on aluminium. 3 refs.

297/81 SELECTIVE RADIATION PROPERTIES OF INDIAN PLASTICS FOR SOLAR HEATING AND NATURAL COOLING OF WATER. J.P. Gupta and M.V.N. Rao (Defence Laboratory, Jodhpur (India)). P. 613-5 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

This paper discusses the selective-radiation properties of polyvinyl chloride (PVC) and polyethylene (polythene) for their possible use in solar heating and the natural cooling of water. PVC is suggested as a cover material for low-temperature solar collectors, green houses and for use in plastic bags for nocturnal cooling of water. On the other hand, polythene is suggested as the material for plastic bags for solar heating and also as cover material for nocturnal natural radiation cooling.

298/81 ELECTROCHEMICAL PHOTOVOLTAIC CELLS FOR SOLAR ENERGY CONVERSION. G. Nagasubramanian and M.V.C. Sastri (Indian Institute of Technology, Madras (India)). P. 379-86 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

A compact polycrystalline sintered Fe_2O_3 pellet was found to respond to the high-flux region of the solar spectrum. Doping with TiO_2 was found to result not only in shifting the U_{fb} to more negative values, but also to increase the collection efficiency. 1% TiO_2-doped Fe_2O_3 was found to yield maximum benefits in both. Results are analysed in terms of the depletion-layer theory.

299/81 PHOTOTHERMAL EFFECT AT TiO_2 ELECTRODES IN A PHOTOELECTRO-CHEMICAL CELL. F. Decker, J. F. Juliao and M. Abramovich (Instituto de Física, Universidade Estadual de Campinas, São Paulo (Brazil)). Applied Physics Letters, vol. 35, p. 397-9 (1979).

An anomalous photoresponse of n-TiO_2 electrodes was previously observed to be induced by light of energy lower than the bandgap, and attributed to surface states at the TiO_2 electrolyte interface. From studies of this effect at stationary and rotating disk TiO_2 electrodes, it was found that the anomalous photo-response is a thermal effect caused by heating of the crystal surface by the illumination. This photothermal effect is claimed to provide a technique for monitoring optical absorption by semiconductor electrodes in solution. 16 refs.

300/81 SOLAR FUELS. J.R. Bolton (Department of Chemistry, University of Western Ontario, London N6A 5B7 (Canada)). Science, vol. 202, p. 705-11 (1978).

This article describes the production of energy-rich compounds by the photochemical conversion and storage of solar energy. The use of such compounds, which are high-calorie fuels and provide a powerful means of converting and storing solar energy, are restricted by thermodynamic and kinetic limitations. The efficiency of conversion from solar to chemical energy is calculated to be 21% at maximum, but will not exceed 13% if storage efficiency is considered. Fuel-generation reactions are considered with special attention given to reactions involving two photosystems absorbing photons in series. A photochemical-reaction system which exhibits high efficiency for producing oxygen and hydrogen by the decomposition of water is proposed. 30 refs.

B1. RADIATION MEASUREMENT

301/81 INEXPENSIVE PORTABLE Cu_2S - CdS RADIOMETER. H.M. Windawi (Institute of Energy Conversion, University of Delaware, Newark, DE 19711 (USA)). Review of Scientific Instruments, vol. 48, p. 1673-5 (1977).

A portable radiometer employing a large-area Cu_2S - CdS solar cell as the sensing element has been used for the measurement of solar-radiation intensity. Its characteristics and calibration are discussed.

B2. PHOTOVOLTAIC CONVERSION

302/81 REVIEW OF CONDUCTOR-INSULATOR-SEMICONDUCTOR (CIS) SOLAR CELLS. R.Singh (Energy Conversion Devices, Inc., 1675 West Maple Road, Troy, MI 48084 (USA)), M.A. Green and K. Rajkanan. Solar Cells, vol. 3, p. 95-148 (1981).

The physics and technology of a new class of photovoltaic devices, namely the conductor-insulator-semiconductor (CIS) solar cells, are reviewed in this paper. The top layer in these diodes may be a transparent conducting metal film, an oxide or polymer semiconductor, an electrolyte or a combination of these, leading to a wide variety of metal-insulator-semiconductor, semiconductor-insulator-semiconductor and electrolyte-insulator-semiconductor structures. The thickness of the interfacial layer and the work function of the conductor are the important parameters in the optimization of these devices. By ensuring inversion at the interface of the base semiconductor, devices can be fabricated with properties which do not depend strongly on the surface states nor on other non-idealities of the interfacial layer. CIS solar cells with efficiencies comparable with the best p-n junction cells have been fabricated. Most of the presentation is related to single-crystal devices, and the non-crystalline (polycrystalline and amorphous) semiconductor devices are treated separately. Available stability and accelerated life-test data indicate fairly stable operation of optimized devices. It is suggested that the research and development efforts have reached such a stage that a prototype production facility is viable. 314 refs.

303/81 ADVANCES IN THEORY, FABRICATION, AND APPLICATIONS OF BIFACIAL SOLAR CELLS. Y. Chevalier and F. Duenas (Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, México (Mexico)). P. 817-23 of Proceedings of the Second EC Photovoltaic Solar Energy Conference (held West Berlin, Fed. Rep. of Germany, 23 Apr. 1979). R.J. Van Overstraeten and W. Palz (eds.), D. Reidel Publishing Co., Hingham, MA, USA (1979).

A theoretical analysis of efficiency and absolute spectral response of bifacial solar cells under back and front illumination is presented. It is shown that, for back illumination, the cell response is strongly dependent on the back-surface recombination velocity. Experimental and theoretical absolute spectral-response curves show an excellent agreement. Measurements show that a reduction in back-surface recombination velocity is obtained by means of SnO_x chemical-spray deposition. However, further investigation is needed in order to reduce the back-surface recombination velocity to values allowing a back response of the bifacial cell similar to its front response. Finally, possible applications of bifacial cells are presented.

304/81 PROGRAM AND PROGRESS OF DST SPONSORED SOLAR PHOTOVOLTAIC WORK IN INDIA. U. Venkateswarlu (Central Electronics Ltd., Sahibabad (India)). P. 427-32 of the Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavhagar, India (1978).

Research, development, and demonstration activities on solar cells in India are described.

305/81 DEVELOPMENT OF HIGH EFFICIENCY CASCADE SOLAR CELLS. QUARTERLY TECHNICAL PROGRESS REPORT NO. 2. Research Triangle Institute, Research Triangle Park, NC (USA)). DSE-4042-T29 (31 Dec. 1979) 15p. NTIS. US$6.50.

Research has continued in the development of selected ternary and quaternary III-V materials that are potential candidates for cascade solar-cell applications. In addition, various simple and multi-junction cascade solar-cell components have been fabricated and evaluated in a continuing study of several different solar-cell designs (combinations of materials) During the present reporting period, work has concentrated on the following major areas: GaAlAs/GaAs cell development; AlGaAsSb/GaAsSb materials development; GaInP materials development via VPE; inverted structure development; and MO-CVD growth system work at North Carolina State University, USA. Progress in each of these areas is summarized.

306/81 DEVELOPMENT OF AN IMPROVED HIGH EFFICIENCY THIN SOLAR CELL. QUARTERLY REPORT. J. Lindmayer, C.V. Wringley and G. Storti (Solarex Corp., Rockville, MD (USA)). N-79-23516 (Jan. 1979) 13p. NTIS. US$7.50.

High efficiency cells (up to 14 AMO at 25 °C) were fabricated from 10-15 Ω-cm silicon by using screen-printed aluminium paste as the alloy source for the production of back-surface fields. Thick-consistency pastes that have been cured prior to a short heat treatment at 850 °C were most effective in achieving these efficiency levels.

307/81 SURVEY OF SEMICONDUCTOR COMBINATIONS FOR OPTIMUM HETEROJUNCTION THIN FILM SOLAR CELLS. G. Vanhoutte and H. Pauwels (University of Ghent, Ghent (Belgium)). P. 662-70 of Proceedings of the Second EC Photovoltaic Solar Energy Conference (held West Berlin, Fed. Rep. of Germany, 23 Apr. 1979). R.J. Van Overstraeten and W. Palz (eds.), D. Reidel Publishing Co., Hingham, MA (USA (1979).

Which combinations of semiconductors can, in principle, give rise to good heterojunction solar cells that can completely be realized in thin-film technology is investigated, and it is verified which of these combinations have already been investigated according to the literature. The heterojunctions are classified according to the discontinuities at the interface in the conduction or valence band. Only those semiconductors are considered that can be realized in purely thin-film technology with the appropriate type and value of conductivity (p, p^+, n or n^+), although thin-film technology may for some of them not yet be sufficiently advanced to realize high collection efficiency. A total of 15 semiconductors are considered in this way, of which 8 can act as absorbers, giving rise to 120 combinations, which are then considered in 6 different types of structures. Those structures that form near-optimum solar cells, and those that have already been investigated in the literature are indicated.

308/81 THE DEVELOPMENT OF PHOTOVOLTAIC CONVERSION SYSTEMS WITH SUNLIGHT CONCENTRATION. Tsuji T. and Mito S. Vol. 1, p. 213-5 of Progress in Batteries and Solar Cells. JEC Press, Inc., Cleveland, OH, USA (1979).

Three concentrators used in the photovoltaic conversion of sunlight are compared. In order of measured optical efficiency, the concentrators are a parabolic cylinder-type concentrator, a compound concentrator (a combination of linear Fresnel lens and a side mirror), and a linear Fresnel lens-type concentrator. The compound concentrator is designed to operate without any tracking mechanism but the other two types are equipped with automatic-tracking units.

309/81 SILICON SOLAR CELL POWER SUPPLY WITH AUTO-TRACKER (自动跟踪硅太阳电池电源). Liáng Shàoxián, Wú Suíchéng and Wáng Xīyì (Xi-an Communication University, Xi-an (China)). Acta Energiae Solaris Sinica (太阳能学报), vol. 2, no. 1, p. 110-2 (1981). In Chinese.

This article describes the circuit and construction of an automatic-tracking system driven by a silicon solar cell powered electricity supply. The results for tracking on both cloudy and clear days are included.

310/81 THE TEST AND USE OF THIN FILM CdS SOLAR CELLS UNDER DIFFERENT LOAD CONDITIONS (薄膜 CdS-Cu_2S 太阳电池不同负载条件下的考验及其试用). Zhāng Ruìfēng (Applied Chemistry Institute, Chinese Academy of Sciences, Zhangchun (China)). Acta Energiae Solaris Sinica (太阳能学报), vol. 2, no. 1, p. 104-9 (1981). In Chinese.

This article describes tests made on CdS thin-film solar cells under various load conditions. The maximum efficiency reported is 5.4%. 10 refs.

311/81 OPERATION OF DC MOTORS POWERED BY PHOTOVOLTAIC CONVERTERS. J. Appelbaum (School of Engineering, Tel Aviv University, Tel Aviv (Israel)). Electric Machines and Electromechanics, vol. 3, p. 209-220 (1979).

Utilization of solar energy (by means of photovoltaic conversion) for driving electromechanical systems in remote places is becoming economically justifiable. Since the output of solar cells is a DC voltage, the DC motor is an obvious candidate for these systems. The performance characteristics (operation and control characteristics) of the separate, series and shunt excitation motors powered by the photovoltaic converter were analysed. These characteristics are different from those of the conventional power supply.

312/81 PHOTOVOLTAIC POWER SYSTEMS MARKET IDENTIFICATION AND ANALYSIS. APPENDICES. (BDM Corp., McLean, VA (USA)). HCP/M2533-01/1 (Nov. 1978) 226p. NTIS. US$16.50.

Topics include: present market analysis (detailed methodology, data, and results); potential photovoltaic application; product-market scenario for rural-electrification application in Iran; product-market scenario for Mexican water pumping and rural electrification; cost assumptions for conventional-energy systems for underground cable used in street and highway lighting; breakeven-cost analysis for photovoltaic power systems for school applications; description of conventional irrigation systems; and technology diffusion in rural India.

B3. ACTIVE THERMAL SYSTEMS

313/81 PRODUCTION AND USE OF ROLLED-WELDED PANELS OF ALUMINUM ALLOYS FOR SOLAR WATER HEATERS OF HOT WATER SUPPLY AND COOLING SYSTEMS. N.I. Koryagin, Y.M. Sigalov, I. Malyknina and Y.N. Malevskii. Applied Solar Energy, vol. 14, no. 6, p. 21-3 (1978) [English translation of Гелиотехника vol. 14, no. 6, p. 26-31 (1978)]. In Russian.

Technology for obtaining rolled-welded panels for solar water heaters is described. For a total solar-radiation density of 500 kcal/m^2h the experimental water-heating equipment could heat 6000 liters of water to a temperature of higher than 50 °C in four to five hours.

314/81 DEVICE FOR PRODUCING USEFUL HEAT FROM SOLAR RADIATION. H. Heitland, R. Kroll and E. Grundmann Cto (Volkswagenwerk AG, Wolfsburg (Fed. Rep. of Germany)). Fed. Rep. of Germany patent no. 2,626,182/A (Dec. 22, 1977). 16p. In German.

A flat collector is described which can be rolled up. The collector consists of at least two foils through which the heat-transfer liquid flows. At least one foil is coloured in order to absorb solar radiation. Technical details on the arrangement of the inlet and outlet ducts and a storage container for the heat-transfer medium are given.

315/81 A METHOD FOR PRODUCING FRESH WATER FROM SEA WATER UTILIZING SOLAR ENERGY (III) (太陽エネルギー利用による海水等から採水する一方法(Ⅲ)). Iida T. (Nihon University, Tokyo (Japan)). P. 117-20 of Proceedings (Kōen Ronbunshū) of the Third Research Presentation Meeting (Dai-sankai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nippon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 5-6 Dec. 1977). Japan Solar Energy Society, Bunkyō-ku, Tokyō, Japan (1977). In Japanese.

Fluid (or a pressurized gas) is circulated through a heat-collecting unit and is then fed to a heat exchanger. The heat exchanger is provided with an air-injecting pipe, and sea water in the heat exchanger is stirred by bubbling. This bubbling results in an increased heat-transfer coefficient and an improved efficiency in fresh-water production. The results of experimental operations are described in detail. 6 refs.

316/81 PERFORMANCE EVALUATION OF SPIRAL SOLAR COLLECTOR. P.K.C. Pillai and R.C. Agarwal (Indian Institute of Technology, New Delhi (India)). P. 153-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

The optimization of the performance of a spiral collector was studied. The length of this collector was optimized for different temperatures and flow rates. An empirical relation was also found for predicting the temperature of the outgoing water for various flow rates and for a particular surface temperature of the spiral.

317/81 SOLAR COLLECTOR FOR RURAL USE. R.K. Saksena and J.V.S. Mani (Birla Institute of Technology and Science, Pilani, Rajasthan (India)). Sunworld, vol. 4, no. 5, p. 168 (1980).

This article describes a simple inexpensive collector which can be produced in a small workshop. It consists mainly of a copper coil and a copper plate. It is coated with fine coke powder, covered with glass and insulated with wool. This collector can be used for a 100-l water heater. 6 refs.

318/81 SOLAR WATER HEATERS IN A DEVELOPING COUNTRY. A. Bachmann (Swiss Association for Technical Assistance, Kathmandu (Nepal)). Vol. 3, p. 1607-11 of Sun: Mankind's Future Source of Energy, Proceedings of the International Solar Energy Congress (held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

Nepal faces many problems arising from soil erosion, increasing population, its landlocked position, and its very limited resources in raw materials. Solar energy has long been used here for the drying of agriculture products. However, with the ever-increasing demand for energy and the exorbitant rise in the expenses involved, attention had to be given to more appropriate ways of using free sun power for purposes other than only crop drying. 3 refs.

319/81 EXPERIENCES WITH A LARGE SIZE SOLAR HOT WATER SYSTEM. U.K. Pandya, A.P. Gulati, N.R. Yardi and B.C. Jain (Jyoti, Limited, Baroda (India)). P. 143-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

With steep increase in fuel prices solar-thermal systems have been found to be increasingly economical. A large solar energy system was installed at Jyoti Limited for supplying hot water to Jyoti Canteen to meet cooling and washing needs. It has now been in operation for more than a year. The experience with this system has shown that large solar hot-water systems can be installed and maintained without any problems. The scaling has been found to be not so serious a problem. There has been no significant change in the system efficiency even after more than a year of operation. It is also clear that such large solar hot-water systems can also be used for process applications without any risk.

320/81 PERFORMANCE OF AN INTERMITTENT AMMONIA-WATER SOLAR REFRIGERATOR OPERATING WITH A FLAT PLATE COLLECTOR. A. Venkatesh and M.C. Gupta (Indian Institute of Technology, Madras (India)). P. 453-72 of Proceedings of the Second International Solar Forum (held Hamburg, Fed. Rep. of Germany, 12 July 1978). Deutsche Gesellschaft für Sonnenenergie eV, München, Fed. Rep. of Germany (1978).

The results of a theoretical analysis of an intermittent ammonia-water solar refrigerator obtained by simulating the processes of the cycle in an IBM 370 computer are presented. Also presented are the experimental results of such a solar refrigerator of 1-m^2 exposed area and a comparison of the theoretical and experimental results in the initial solution concentration range of 0.5 to 0.65.

321/81 THE DESICCANT/ROCK BED METHOD OF SOLAR COOLING WITH AIR COLLECTORS. D.B. Meredith and P.J. Wilbur (Pennsylvania State University, Uniontown, PA 15401 (USA)). P. 274-7 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, WA, USA (1979).

A method of air-conditioning buildings using solar energy is presented. This includes a fixed desiccant bed, evaporation collector, the necessary control systems and the usual components of an air-heating solar energy system. A simulation model used to study the thermal characteristics of the system under normal insolation and climatic conditions was constructed. 7 refs.

322/81 SOLAR-HEATING, FORCED-AIR, LUMBER DRYER FOR TROPICAL LATITUDES. J.A. Tschernitz and W.T. Simpson (Forest Products Laboratory, US Department of Agriculture, Madison, WI 53705 (USA)). Solar Energy, vol. 22, p. 563-6 (1979).

This article describes the characteristics of a solar lumber dryer developed by the Forest Products Laboratory for the purpose of demonstrating the use of small- and medium-capacity lumber dryers in developing countries. The results obtained are compared with ordinary air drying of lumber. With local fabrication in the Philippines, a dryer was constructed with a capacity of 2.4 m^3 per week at the maximum cost of US$5,000 in 1977. 3 refs.

323/81 SOLAR HEATED LUMBER DRY KILN. S.J. Robertson and D.V. Merrifield (Lockheed-Huntsville Research and Engineering Center, Huntsville, AL (USA)). P. 51-61 of Proceedings of the Solar Industry Heating Procen Conference (held Denver, CO, USA, 18 Oct. 1978). SERI/TP-49-065 (1978). NTIS. US$15.50 for complete proceedings.

A solar energy system was constructed and is currently being tested for supplying heat to two 17,000 board-meter capacity lumber-drying kilns. The solar energy system consists of 233 m^2 of double-glazed flat-plate collectors with a black-chrome selective coating, a 19,000-liter steel storage tank for storing heated water and approximately 200 m of fin-pipe heat exchangers for each kiln. The solar energy system has been operating and supplying heat to the kilns since November 1977. The collector efficiencies have averaged about 45% during the time that good data were available, and the energy supplied to the kilns averaged about 24.4 kilowatts, about 44% of the energy requirement for one kiln.

B4. PASSIVE THERMAL SYSTEMS

324/81 PASSIVE SOLAR ENERGY COLLECTOR: FINAL REPORT. Eikonix Corp., Burlington, MA (USA)). ALO-4125-11 (3 May 1978) 38p. NTIS. US$8.50.

The objective of this research programme was to validate the applicability of poroplastic filled with wax (and other wax-filled plastic host materials) as volumetric absorbers of solar energy, storing energy as a result of a phase change. Moreover, an attempt was made to show that a passive solar collector-convector of the Trombe-wall type could store a meaningful amount of heat and could be fabricated using these materials. The research findings were encouraging, indicating that multilayer elements would absorb sufficient energy when exposed to the December afternoon sun in New England, USA, to undergo phase change at about 52 °C. A second important finding was that the wax-filled poroplastic acts as a light valve upon undergoing phase change. Upon melting, optical transmission in the visible region of the spectrum increases by a factor of two, making it possible to clearly see through the absorber layer. In the infrared portion of the spectrum, the change between radiant-energy transmission from the liquid state to the solid state was reduced by a factor of three. Thus, poroplastic filled with wax can act as a passive curtain for Trombe-wall solar collectors, isolating the warm wall surface of the solar collector from the nighttime sky as it solidifies. Reduction of nighttime radiation losses by this method could significantly improve performance of some types of solar energy systems. The research effort has shown that the goals of the encapsulated-wax passive collector concept can be met and that such a collector-convector system can be designed and operated satisfactorily at reasonable cost. Based upon the results of the experimental work it is estimated that such a collector could store between 670 and 840 kcal/m^2 in the form of latent heat of fusion of the wax at a weight of 12.7 kg/m^2 for the absorber-storage portion of the collector.

325/81 THE USE OF SODIUM SULFATE IN SOLAR PONDS. J. Mangussi, L. Saravia and G. Lesino (Departamento de Ciencias Exactas, Universidad Nacional de Salta, 4400 Salta (Argentina)). Solar Energy vol. 25, p. 475-7 (1980).

The use of salts with significantly temperature-dependent saturation concentrations has been proposed to avoid the problem of destruction of the salt gradient in solar ponds due to diffusion. If the concentration at different depths is maintained near saturation, salt diffusion produces super saturation. Then, the salt crystallizes, and falls to the bottom of the pond, from where it diffuses again, completing the cycle. Sodium sulfate is a salt with the appropriate properties up to 32.4 °C, above which the saturation-density derivative with temperature is no longer positive. To overcome this difficulty, a working scheme is presented wherein the concentration, as a function of depth, is such that the pond is saturated only near its surface. It is interesting to note that such surface-saturated ponds operate with a much smaller amount of salt than required for saturated operation. In the article, the concentration profile of such a pond is discussed and some experiments performed over the last three years with laboratory models are described. 4 refs.

326/81 A SIMPLE METHOD TO ESTABLISH SALT GRADIENT SOLAR PONDS. F. Zangrando (Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM 87131 (USA)). Solar Energy, vol. 25, p. 467-70 (1980).

Salt-gradient solar ponds, combining collection with seasonal storage, are considered to be one of the cheapest solar energy systems available today, with potential widespread applications in solar heating and cooling, as well as industrial-process heat. Until recently the salinity gradient of such ponds was painstakingly established by superposing progressively less-dense brine, a method that is cumbersome, time consuming and expensive for any commercial application. This note describes a new technique developed at the University of New Mexico that is the simplest and most expedient way to establish and modify a gradient. The technique, which involves the injection of fresh water alone, was tested at the University of New Mexico pond and was used to establish the 1.3-m thick gradient of the newly built solar pond in Miamisburg, OH, USA, with a surface of 2000 m^2. 5 refs.

327/81 SEDE SOQUER, SHALLOW SOLAR PONDS PROJECT. A.I. Kudish and A. Roy (Institute of Desert Research, Ben Gurion University, Beer Sheva (Israel)). P. 62-5 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, WA, USA (1979).

The results of operating three 2 x 1.3-m shallow solar ponds from July 1978 are presented. Each pond had the same lower black PVC sheet, but different transparent-cover sheets. The average daily efficiencies were determined for each month. 5 refs.

328/81 SOLAR DRYING POTATOES. A. Shaw (International Potato Center, Apartado 5969, Lima (Peru)). Appropriate Technology, vol. 7, no. 4, p. 26-7 (1980).

This article presents a method for processing cooked shredded potatoes. The potatoes are dehydrated by using a combination of wind and sun energy. The two-stage dryer (developed in Huancaya, Peru) first subjects the potatoes to wind-energy dehydration over night (about 18 hours), followed by processing using both wind and solar energy to reduce the moisture content from 45%, after the first stage, to the necessary 10%. The second stage takes about 2-3 hours.

329/81 YEAR ROUND OPERATION AND ECONOMICS OF ONE TON/DAY SOLAR PADDY DRYER. V.R. Muthuveerappan and K. Iynkaran (Annamalai University, Annamalainagar (India)). P. 665-9 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

A roof-cum-solar collector was successfully designed, fabricated and tested for one year under actual working conditions for grain-drying applications at Annamalai University. This paper presents the year-round experimental results obtained. The process drying of paddy and the advantages and economics of using solar energy for drying are discussed. Instrumentation details are briefly specified. The difficulties encountered during the year-round operation and maintenance are dealt with. Future designs and applications are specified at the end of this paper.

330/81 TECHNICAL AND ECONOMIC PERFORMANCES OF SOLAR GREENHOUSES USING HEATING COLLECTION IN THE GROUND. V.P. Agadzhanov, L.E. Rybakova and A.D. Ushakova (Institute of Solar Energy, Turkmen SSR Academy of Sciences, Ashkhabad, Turkmen SSR (USSR)). Известия Академий Наук Туркменской ССР Серия Физико-Технических, Химических и Геологических Наук (Transactions of the Turkmen SSR Academy of Sciences: Physico-technical, Chemical and Geological Series), no. 2, p. 112-5 (1980). In Russian.

This abstract presents the results of a solar greenhouse experiment in Turkmen SSR, USSR, from both the technical and economic viewpoints. 4 refs.

331/81 JAPANESE STYLE UTILIZATION OF SOLAR HEAT BOXES (太陽光による熱箱の日本的な利用法について). Fujinaka M. (Tokyo Electrical Engineering College, Chiyoda-ku, Tokyō (Japan)). P. 29-32 of Proceedings (Kōen Ronbunshū) of the Fourth Research Presentation Meeting (Dai-Yonkai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nippon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 27-28 Feb. 1978). Japan Solar Energy Society, Bunkyō-ku, Tokyō, Japan (1978). In Japanese.

The applications of heat boxes to hot-water bottles, bed warmers, braziers, foot warmers, and kotatsu (Japanese style leg warmers) were tried as simple and inexpensive methods for the utilization of solar heat. The heat box is made of metal or polypropylene (27 x 30 x 1 cm) and is filled with a heat-storage material utilizing latent heat (such as polyethylene glycol or sodium thiosulfate). The heat box is painted black on its surfaces. Radiative cooling curves and the results of utilization are described. 7 refs.

C. BIOCONVERSION ENERGY

332/81 THE STATUS OF SOLAR ENERGY AS FUEL. D.O. Hall (Department of Plant Sciences, University of London King's College, London (UK)). Impact of Science on Society, vol. 29, p. 307-17 (1979).

The biological conversion of solar energy via photosynthesis produces each year an amount of stored energy, in the form of biomass, about ten times the world's annual consumption. The amount of proven fossil-fuel reserves underground equals the present standing biomass (mostly trees) on the earth's surface, while fossil-fuel resources may be ten times this

UNCNRSE
CONFERENCE NEWS 7

SEC.GEN. ADDRESSES THIRD PREPARATORY SESSION

The Preparatory Committee for the UN Conference on New and Renewable Sources of Energy (UNCNRSE) met in its third session from 30 March to 17 April 1981 to continue its work in formulating a programme of action for the Conference.

Mr. Enrique Iglesias addressed the Preparatory Committee for the first time in his new capacity as Secretary-General of the Conference. He noted the diligence with which the Conference Secretariat had carried out the heavy workload assigned to it by the Preparatory Committee under the leadership of his predecessor, Mr. M. Gherab. He also noted the valuable co-operation provided by the governments of Member States, experts, units of the United Nations system and non-governmental organizations. He called the particular attention to the valuable contribution and support made by the Government of Kenya in hosting this Conference.

The Conference Secretary-General then reviewed some of the technical conclusions that were derived from the preparatory phase including the relevance and significance of NRSE, their very different stages of evolution, the economic aspects of their development and utilization, their efficiency, the gaps which remain in present knowledge and information about the development and utilization of these sources, and the ecological implications of these new alternatives. He indicated that the energy transition designed to diversify the present energy base of humankind must be firmly linked to NRSE. Furthermore, energy is traditionally considered as a fundamental and essential input to the development process. What is required now is the planning of certain development processes for the creation of new sources of energy. Thus, the subject of the Conference acquires a new dimension with development and the creation of energy as elements in a mutually reinforcing process.

In his message the Secretary-General of the Conference noted that within the scope of the Conference, the following five concepts may be used by the governments as a background for their deliberation:

1) the awareness of the role of NRSE in the energy transition of humankind;
2) enhancement of the national decision-making capacity in the field of NRSE;
3) the launching of a programme of international co-operation for the development of NRSE;
4) stimulation of national utilization and international transfer of resources which will enhance the application of NRSE; and
5) mobilization and intensification of activities of the United Nations system in the field of NRSE.

When considering a programme of international co-operation for the development of NRSE, Mr. Iglesias noted two types of transition, the first for traditional societies in rural areas and the second for modern societies.

With the preparatory process now largely behind the Conference Secretariat, the following work can now proceed:

1) the preparation and discussion of a draft world programme of action for the development of NRSE;
2) the possibility of initiating an additional information programme on the results of the preparatory phase, dealing with the potential for new alternative energy sources and the needs for national organization and international co-operation; and
3) an acceleration of the public information programme.

The Conference Secretary-General concluded that the importance of the subject with which the Conference will deal is clearly apparent and that there is a direct relationship between the policy for NRSE and the general policy for development in developing nations. Since the energy transition is the global responsibility of the entire international community, this Conference proposes an appeal for international co-operation at all levels in undertaking this responsibility.

The deliberations and results to the Preparatory Committee will be included in the next issue.

SUMMARY: SYNTHESIS REPORT

The task of the Synthesis Group was: to provide a bridge between the technical and other detailed preparatory investigative groups, and to arrive at recommendations, or findings, for deliberation by the third and fourth sessions of the Preparatory Committee. Composed of experts from various fields and representatives of UN bodies and specialized agencies, the Synthesis Group studied the Reports of the Technical Panels and the Ad Hoc Groups of Experts and after discussions adopted the Synthesis Report on 25 February 1981.

In drafting this Report, the Synthesis Group first summarized the rationale and background of the Confer-

This section of *ASSET (Abstracts of Selected Solar Energy Technology)* is devoted to the UN Conference on New and Renewable Sources of Energy and is published by the UN University with the co-operation of the UNCNRSE Secretariat and the UN Division for Economic and

ence. It then outlined technological and economic prospects for energy development. From the Ad Hoc Reports, the Group understood that a basic constraint limiting the wider application of new and renewable sources of energy (NRSE) was the lack of political commitment by governments and the difficulty governments had in identifying and setting priorities in the energy field. It then tried to determine the constraints of research, development and the transfer of technology, education and training, financing, information flow and socio-economic and environmental issues. With these in mind, the relationships between energy and development were considered. The Synthesis Report concludes with an overview of the energy situation and prospects and points out the key elements needed to achieve increased use of NRSE at both the national and international levels. The following is a summary of the Reports.

I. INTRODUCTION

There is a manifest common interest to set in motion a series of measures which will enable all countries to be assured of the necessary energy supply for their development needs over the next few decades and possibly to move towards a greater degree of energy self-sufficiency. The rate of increase in oil consumption will have to slow down significantly as oil is likely to reach its peak as the dominant global energy source before the year 2000. Thus, the world community will, sooner than previously visualized, have to make a relatively rapid transition to radically new energy mixes. So far, neither national-policy formulation nor international co-operative efforts have been adequate to bring about the global changes required; planning, financing, priority-setting, popular acceptance and consultation all take time, and policy decisions are therefore urgently required to bring into use alternative sources of energy. Thus, a major challenge for mankind in years to come will be to implement a coherent series of policies at national, regional and world levels during this transitional period, aimed at moving from the present energy-limited basis to a more sustainable and diversified structure of energy demand and supply.

It is generally estimated that the present contribution of NRSE to the total energy supply, on a world average, amounts to some 15%. However, this figure is uncertain due to the unrecorded contribution of some commercial and non-commercial traditional energy sources, particularly draught animal power and biomass. Most projections contend that, if even modest development objectives are to be realized, energy consumption in developing countries will need to rise by about threefold in the coming twenty years and that the contribution of new and renewable sources to world energy supply will need to rise from the present level to about 25%, i.e. almost doubling its percentage contribution. In the coming decades this amounts to a five- or six-fold increase in absolute terms. The implications of this challenge are far-reaching, involving structural changes in the world economy, particularly with respect to financial flows and socio-economic and technological factors. This has profound implications for the rural sector where even a relatively small per capita increment will result in a major improvement in quality of life in terms of improved health, education and income for those billions who will be directly affected.

II. TECHNOLOGICAL AND ECONOMIC PROSPECTS

In economic and technological terms, general worldwide application of new and renewable energy technologies is already practicable. Several are now feasible and call for rapid development while others are already in widespread use. Those technologies that have a modular character have inherent technical, social, economic and political advantages, and can be of great benefit, especially to the rural populations of developing countries by virtue of their potential for delivering energy within reasonable lead times.

The potential for the development and use of these technologies at the desired level exists in both industrialized and developing countries. However, there are difficulties associated with their "newness" and appropriate efforts may be required to assimilate them into the social and cultural life. Factors which must be considered in the evaluation of an NRSE technology include the interchangeability of energy resources, degree of site specificity, scale of production, resource base, maturity of the technology, end-use efficiency and other conventional financial cost-benefit factors, and social costs and benefits. Account must be taken of the needs of those who will be the end-users of these technologies and should be considered through a comprehensive systems approach to the supply and use of energy in all forms.

The energy problems of many developing countries centre on their great dependence on draught-animal power and fuelwood. These are estimated to account for about 10% of the total world-energy consumption, but, more important, they are the primary energy resources for the rural sectors in which close to one half of mankind lives. Thus, forest resources have been heavily depleted, bringing adverse environmental consequences as well as a severe shortage of firewood. The preliminary results of a study of fuelwood supply and needs indicate that about 100 million people in developing countries live in areas where there is already an acute shortage of firewood. About another 1,000 million are able to meet their minimum firewood requirements only by cutting in excess of sustainable supply. Under current trends of population growth, of fuelwood demands and of depletion of tree resources, over 2,300 million rural people in developing countries will need, within two decades, to be provided with large supplies of alternative fuels.

Renewable energy can be examined in the light of four basic forms of energy use, namely: liquid transport fuels, centralized electric power, decentralized power and heat. These are outlined in the adjacent table. The comparative costs and future prospects where known for each of the items in the table are provided in an appendix of the Report. Among new and renewable energy technologies, minihydro, small-scale solar and biomethanation are already feasible and available for rapid proliferation in a decentralized mode. Large-scale hydro, geothermal and, to some extent, tidal power will continue to play important roles in centralized networks which principally benefit urban areas. The prospects for other biomass and peat technology such as the production of solid, liquid and gaseous fuels are of considerable interest and provided that there are no conflicts with food production, the scope is fairly wide, even in the short-term perspective. Small-scale solar technologies for water pumping and distillation, low-temperature heating, cooking,

Table 1. New and renewable energy technologies and application

	Energy sources	Liquid transport fuels	Centralized electric power	Decentralized power	Heat
1.	Solar		Thermal electric Photovoltaic Solar pond	Thermal electric Photovoltaic	Solar passive Solar pond Solar flat plate Evacuated tube Solar cookers Solar concentrators
2.	Geothermal		Geothermal electric	Geothermal small power	Geothermal Direct heat
3.	Wind			Wind electric	Wind electric Wind shaft
4.	Hydropower		Hydropower (including small hydro)	Mini hydro	
5.	Biomass	Ethanol Methanol Vegetable oils	Direct combustion	1. Diesel with liquid biofuel 2. Diesel with producer gas 3. Diesel with biogas 4. Direct combustion 5. Fuel cells based on liquid/gas fuel	1. Direct combustion 2. Biogas 3. Producer gas
6.	Fuelwood and charcoal		Direct combustion		Direct combustion of wood and charcoal
7.	Oil shale and tar sands	Syn-crude	Shale burning		Liquid fuel for cooking
8.	Ocean energy		Tidal OTEC Wave	Wave	
9.	Peat	Methanol	Direct combustion	1. Direct combustion 2. Gasification	Direct combustion
10.	Draught animal			Traction and shaft power	

crop drying and power generation are available and are expected to play a significant role in the near future. Small- and medium-size windmills used in a decentralized mode are already cost-competitive in many areas whereas medium and large windmills are expected to be attractive enough for autonomous and integrated modes of operation in windy areas. Other new and renewable energy technologies such as OTEC, geothermal energy, large-scale solar power, tar sands and oil shales are very promising; with suitable support for research, development and demonstration these could emerge as significant options in short to medium-term time frames.

While the energy transition presents all nations with both technological and development strategy options, the choices open to developing and countries provide them, in principle, with a unique challenging opportunity to increase their technological self-reliance as well as to determine the pattern of their future development based on a flexible energy-development relationship.

One advantageous feature of NRSE is that several forms are particularly well suited for decentralized development and where other forms of energy may be difficult or expensive to obtain. The long-run economic and social benefits should be considered even when the initial capital cost is higher than that of energy from conventional sources. The fact that renewable energy can be made available to large numbers of poor people relatively quickly should be of overriding importance. These programmes can be better assimilated in rural areas if local people are involved in their development, fabrication, operation and maintenance. It is from this perspective that the use of NRSE should be seen.

III. PROBLEMS INVOLVED IN THE APPLICATION OF NRSE TECHNOLOGIES

Principal Constraints

There is a need for long-term (20 years or more) as well as short- and medium-term national energy policies that take into account the development and use of NRSE as a whole. Such policies should recognize the role of energy as an important element and as a driving force for development. A long-term policy is essential because there is usually a long time lag between decisions related to energy and the implementation of these decisions. It is necessary also because there must be a long-term political commitment by governments to tasks such as research and development or raising awareness if NRSE are to be widely adopted. Energy technologies and applications for new, conventional and traditional sources affect practically all social, cultural and economic issues at national and international levels.

The key issue in the role of energy in development is proper policy planning. Relatively few industrialized and developing countries have so far formulated and implemented proper national energy policies. In many cases energy plans, when they exist, contain the following short-comings:

(a) plans and projects are often still based on the assumption of relatively cheap energy sources, and on established consumption patterns of oil and electricity;

(b) estimates of future needs for energy are seldom based on an adequate analysis of the demand side of the energy equation, and rural energy demand is particularly liable to be neglected;

(c) plans for energy and plans for other sectors of the economy are made independently of each other, thus resulting in a mismatch between the objectives of energy planning and the objectives of over-all social and economic development; and

(d) energy plans often neglect the present contribution and future potential of both new and traditional renewable sources of energy and frequently do not take account of the favourable foreign exchange implications that such new sources may have.

Additional Constraints on the Development and Utilization of NRSE

The limited human, technical and financial resources that are available greatly restrict the scope of research, development and demonstration projects which can be undertaken by many developing and industrialized countries. In order for the developing countries to get the most benefit from the use of NRSE, the research and development work that is undertaken should be aimed at improving the productivity of their national-resource base, and must be clearly relevant to the needs of end-users, whether these are in the traditional or modern sectors of the economy. Further work may also be required to develop suitable end-use equipment to utilize this energy, thus maximizing economic and social impacts.

The problem of adapting both imported (potentially restrictive and leading to long-term technological dependence) and local energy technologies to meet local conditions must be given due recognition. This is a most important constraint. Fortunately, several promising technologies that are well suited to the ecological and socio-economic conditions of rural areas have been developed and their transfer among developing countries should be promoted and supported.

Research and development needs are determined primarily in terms of the probable end-uses of the new sources of energy. The end-users, however, are in many cases the whole population. It is not, therefore, only a matter of training those who will be concerned with the development and supply of new and renewable energy; there is an immense task required in all countries to ensure that people are aware of the opportunities that new sources offer for meeting their energy needs, often through relatively simple techniques. To create this widespread awareness will require the imaginative use of many forms of communication (from demonstration projects to the mass media) and educational programmes on all levels.

Since most existing information systems and services are oriented towards users in industrialized countries, access to this information for people in developing countries is costly and difficult. In addition, all sectors in the developing countries face an unmet need for practical and relevant information from other developing countries which have conditions comparable to their own. Existing data banks are mainly focused on conventional commercial sources of energy and have been most useful for energy systems in industrialized countries. Economic data needed for policy and investment decisions are not readily available for use either in industrialized or developing countries, nor are evaluative and comparative data on various new energy technologies available though generalized data for resource assessment are now being collected for many parts of the world. What is also needed is the detailed data necessary for in-depth assessments connected with programme and project preparations. This includes the abundant and relevant scientific and technical information (including patent reports) that exists, but is not readily available to the developing countries. Some developing countries are already harnessing various technologies, traditional and modern, in the field of NRSE and have access to information, through their own research and development activities, pilot and demonstration projects and links established with external sources of information and advice. But such information is not accessible to those developing countries which lack an information delivery infrastructure and have limited access to seminars, conferences, study tours and other information exchange facilities.

In addition to technical and institutional problems of the kind examined by the Technical Panels and Ad Hoc Groups of Experts, there may be other significant constraints on the development and wider use of NRSE. For example, socio-economic conditions affect individual behaviour and perceptions in regard to the use of energy. Cultural traditions must be respected, and energy proposals incorporated into such patterns. Any technological innovation should enrich the culture and the heritage, not destroy them. Laws and regulations (especially in regard to electricity supply) may deter the adoption of NRSE in ways that were neither intended nor foreseen when the statutes were drafted. Environmental considerations also need to be considered, as they do with all forms of energy development. Like the constraints already described, such factors need not be permanent barriers to the use of these sources of energy, but their influence cannot be underestimated. In some circumstances considerable time and effort may be required to overcome their effects.

It is difficult to access the precise financial requirements of future energy development in the widest sense. The difficulty stems from a variety of factors inherent in forecasting, including the uncertainty of energy prices and the investment requriements and operating costs of new sources of energy. Specific issues that need to be tackled effectively and urgently, if the necessary finance is to be provided, include the following:

(a) Individual countries will need to undertake pre-investment studies to determine where financial investments are likely to yield the greatest benefits. This will also require consideration of forms and uses of energy that have attracted little investment in the past, but where small improvements may have widespread effects on large groups in the population (e.g. charcoal kilns and draught animal power).

(b) Financial requirements from external sources should be determined after taking into account the national energy resource base, the national-investment potential and national policies in regard to the use of external financial resources.

(c) Some technologies may require less external capital and may, therefore, be more attractive in the overall context of national development because the technologies are decentralized and therefore lend themselves to community self-help projects, with much of the needed investment (of labour as well as capital) coming from within the community itself.

IV. ENERGY AND DEVELOPMENT

The rate and character of development have traditionally been strongly influenced by the availability, form and cost of energy. The abundant and low cost energy of the past provided a number of countries with an adequate base for rapid development. The gap in living standards separating the affluent countries from the poorer countries, and affluent regions from poorer regions, can sometimes be closely correlated to inequities in energy supplies, indicated both by the quantity of energy available and by the efficiency with which it is used. This economic gap between nations and the associated economic dependence of the poorer countries will continue to grow, together with greater world economic imbalances, unless great efforts are made, along new energy paths, to expand their indigenous energy supplies from both conventional and non-conventional sources. It is practically impossible, for developing and industrialized countries, alike, to pursue the same path of development within the present constraints of the scarcity and price of conventional energy resources. For the next two decades, perhaps, the decisions on various development strategies must feature energy as the cardianl point.

In view of the very limited purchasing power of the population in most rural areas, alternative ways to provide energy have to be devised. The long-run economic and social benefits to be obtained from the application of NRSE should be considered, even where the initial capital cost is higher than that of energy from conventional sources. The fact that energy can be made available to large numbers of poor people relatively quickly should be of overriding importance. NRSE programmes can be better assimilated in rural areas if local people are involved in their development, fabrication, operation and maintenance. Very small increases in the supply of electricity or fuels can bring substantial changes in the character and quality of local life, including: increased agricultural productivity; development of local industry and transport systems; increased efficiency of the household; provision of reliable water supplies; and improved communication, education and health.

Much of the food in developing countries is produced, transported and processed by human and animal power, both of which may be categorized as renewable forms of energy, often used very inefficiently in economic terms, and representing time-consuming drudgery from a social viewpoint. The potential economic and social benefits from more effective use of traditional and the development of NRSE are thus tantalizingly great. In addition, agricultural development can take advantage of new energy sources for additional irrigation, crop drying, fertilizers, etc. while at the same time using conventional renewables such as draught-animal power, fuelwood and biomass more effectively.

There is great potential for increasing energy and its efficiency in household use, which is of major importance to those living in rural communities. If women and children were not required to spend so much of their time gathering fuelwood, they might then have time and energy available for education, training and other activities. The selective use of small-scale integrated energy systems could be one of the most significant early applications of NRSE.

The task of rural development cannot be tackled effectively unless additional employment and income opportunities are generated to create gainful non-farm employment in rural areas, particularly in agro-based industry.

The industrial sector is a major consumer of commercial energy. Assessments of the impact of new sources of energy must take into account the quantity, cost, type and quality of energy required by different industrial processes. The urban areas of the developing world are in general growing much more rapidly than the total population and in order for the urban systems to function well, they need reliable access to the most adequate energy sources. It is expected that the need for energy will increase rapidly in developing countries as they establish major industrial plans. Sometimes plans are conceived without adequate consideration of the constraints on energy that exist in each country. To ease the pressure on conventional sources of energy, it may be necessary to review national industrialization strategies in terms of available energy supplies.

Energy requirements of the transportation sector present a major financial burden for most of the non-oil-producing countries. Some renewable energy options, such as methanol from gasification, synthetic fuels from liquefaction, and oils from hydrocarbon plants, can contribute to the solution of this problem. These options should receive greater developmental support. Other renewable technologies, such as the use of ethanol, vegetable oils, and producer and biogas engines, are currently available. Greater use may be made of alcohol-powered internal combustion engines (provided that this does not lead to undesirable competition for land with other crops) and of transport systems that use electricity from alternative sources of energy.

Conventional commercial energy supply in practically all countries is an elaborately organized system. Similar arrangements and responsibilities need to be established in regard to the use of NRSE, taking into account the small-scale and decentralized character of many applications. The organization of regular maintenance, repair and the supply of spare parts should probably therefore also be based on a decentralized approach.

V. RECOMMENDATIONS

It must be stressed at the outset that increased efforts are called for on national and international levels and that both must be mutually reinforcing. Already much is being done; at the national level many countries have initiated significant programmes to develop and utilize new energy sources. Similarly extensive work on various aspects of NRSE is already underway in many bodies and agencies of the United Nations system, as well as in other intergovernmental and non-governmental bodies.

Areas requiring national attention

Coherent national energy policies and plans need to be formulated that provide a framework for defining the role of alternative sources of energy in the economy, for determining priorities among the various technologies, and for assigning resources accordingly. These energy policies and plans must constitute integral parts of broader development strategies and take adequate account of the nature of the end-use of the energy. All countries will need to pay particular attention to the strengthening of their policy formulation, development planning and project management capabilities. This will particularly assist developing countries to increase their absorptive capacity for assistance in the field of NRSE, and promote external financial and technological flows into these sources.

It is important to use existing, or create, appropriate institutional frameworks to serve as a basis for activities in research, development, planning, production and use of NRSE. Furthermore, a reliable data base must be established to permit the effective evaluation of resources which may serve as alternative sources of energy.

Once the character of the resource base has been established, pre-investment studies will be required to determine whether attractive investment opportunities exist, the extent of equipment adaptation necessary and problems of acceptability. The development of a strong research and development capacity in developing countries would be an important step in facilitating the evaluation of available technologies and in adapting and innovating suitable technologies for NRSE. The research and development capabilities of industrialized countries might also make contributions to meeting the particular needs of developing countries.

As part of the development of a national information programme, appropriate extension services are necessary to encourage and promote the acceptance and use of NRSE. An appropriate national agency should be designated as a focal point for a broad range of responsibilities for information (inventories, data bases, communications, etc.), so as to meet the needs of specific user groups. A first step might be a detailed analysis of the existing local information infrastructure and its capability to meet demands for information about NRSE.

Education and training regarding NRSE should be incorporated in formal programmes at all levels, and programmes should also be developed to encourage the public at large to contribute to the widespread use of these sources.

It is important to examine the effect of existing laws and regulations on the development and use of NRSE, and to introduce new legal and quasi-legal mechanisms to encourage their use.

Financial incentives, for example, subsidies, tax rebates, etc., may be necessary to stimulate user and producer interest in NRSE, especially where energy from conventional sources is not priced at economic levels. All countries should make every effort to enhance their mobilization of domestic investment resources for NRSE and developing countries should take steps to benefit fully from international financial co-operation in this area. Imaginative and innovative schemes for financing energy investments at the small-scale and local level should also be explored and implemented whenever possible.

It is also important to recognize that programmes aimed at enhancing the use of NRSE should include adequate energy pricing systems and appropriate allocations of resources for the different investment purposes, both through public and private channels. In that respect innovative policies should be pursued to increase the investment capacity of different sections of the population through mobilization of natural and human resources.

Areas requiring attention of the international community

Inadequate energy planning and inadequate integration of such planning with national industrial or other development policies have been major impediments to international co-operation in new and renewable energy technologies. National policies to improve project formulation and evaluation and better training, infrastructural and institutional support, are the prerequisites to greater international co-operation.

However, national policies to encourage the rapid adoption and greater use of new and renewable energy technologies should be accompanied by corresponding international action. Governments will wish to consider what steps should be taken at the policy-decision level throughout the UN system, including the specialized agencies, and in other international organizations to reflect the strengthening resolve of the world community to give greater emphasis to these energy sources. In particular, the medium-term plans and policies and the programmes and projects and other financial outlays of these institutions should take full account of the greater potential of NRSE which is now warranted on technological, economic and other grounds. Fully multi-lateral, limited regional and even bilateral co-operation efforts will need to be drawn upon.

In order to adapt and adopt both transferred and indigenous technologies that meet specific energy needs, an effective system of collaboration between countries is required. This would enable developing countries to strengthen their research, development and demonstration resources, and the international community should ensure that this receives due recognition in all energy programmes. Such collaboration may take the form both of direct technical and financial support to strengthen national, and in particular developing country, research and development programmes, and of support for bilateral, regional and international programmes in areas where co-operative research efforts are likely to prove particularly effective. Twinning arangements between industrialized and developing and among developing countries themselves would be a means of ensuring such collaboration.

Developing countries should be assisted in strengthening their capacity to develop suitable equipment which will have maximum economic and social impact. This could include systems engineering, demonstration, fabrication and distribution techniques.

There is a clear need to improve the productivity and use of existing national energy resources especially those most relevant to end-users. Both energy and financial efficiencies should be considered in this context in addition to the importance of attaining a degree of national energy independence. International assistance could clearly stimulate such research and development. An example is the use of the existing international and national agricultural and forestry research institutes for selecting and breeding high-yielding and stress-resistant energy crops and trees, and for developing better breeds of draught animals.

An international awareness should be created of the opportunities which exist in the field of NRSE. The media should be used to bring this message to all those from the end-users up to the decision-makers, managers, planners and local entrepreneurs. The non-governmental organizations have an important role to play and this should be encouraged by the international community.

Currently there are few courses or training programmes in NRSE available anywhere in the world, and there is a known significant shortage of qualified manpower in this field. The expansion or creation of national, regional and international centres could play a vital role in implementing these needed education and training programmes. Training courses aimed at specific groups would include professionals such as scientists and technologists, energy planners, educators, extension officers, technicians and public users of new and renewable energy technologies.

In order to provide practical and relevant information about NRSE, and their application, to planners, policy-makers, technologists and educators in all countries, sustained information analysis and evaluation activities should be established. Such information on currently available and emerging technologies should be especially helpful to developing countries.

Existing data banks on energy could be expanded to include adequate data on NRSE and to collate the information from national and regional energy surveys already available or in the process of being performed. Mechanisms could perhaps be developed to link these sources into an effective international information system.

National and regional centres for NRSE should be developed and strengthened. These centres should be given responsibility for resource assessment; evaluation; research, development and demonstration of appropriate technologies; information dissemination; and training. There is a need to develop regional co-operative network programmes based on regional needs and linking such centres, to accelerate the development and use of NRSE. Such a system would require only a small administrative infrastructure, which could be provided at reasonable cost.

In order that all countries, especially developing countries, can being to take greater advantage of traditional and NRSE, demonstration projects should be organized with some urgency, preferably on a commercial scale. These could be in terms of small-scale technologies for stand-alone operation in rural areas; autonomous operation of a mix of various traditional and new and renewable energy technologies on a small and medium scale; and in conjunction with integrated electricity networks.

The Conference may wish to consider the precise forms and areas of particular collaborative efforts which might be encouraged. Governments may wish to examine, in the light of on-going efforts, the priorities of the various organs, organizations and bodies of the UN system, to bring international and regional co-operative activities into line with a new thrust in favour of new and renewable energy technologies. The Conference may also wish to consider institutional arrangements appropriate to such international co-operation, although the Synthesis Group has not examined these aspects in any detail. However it has considered the general question of financing in relation to its other conclusions, and has made the following preliminary observations.

The investment required to develop new energy technologies calls for significant additional financial efforts. From examination of World Bank estimates for the period 1981-1985, and other estimates, it appears that the financial resources needed for investment in NRSE other than large hydropower in developing countries alone could amount to as much as $12 billion. Some of the financial resources may be derived as the world community makes progress on disarmament and international security, and towards international economic equilibrium and growth.

Multilateral development lending institutions have an important role to play in financing the development and application of new and renewable energy technologies particularly in the developing countries. They need to increase their support for these sources of energy in general, and to meet rural energy needs in particular. This could be achieved partly by according NRSE a higher priority within the sectoral allocation of available funds. Additional resources in the form of equity capital will in all probability be needed, in order to enhance their ability to obtain funds for development lending by borrowing on world markets. It is also likely that additional resources for concessional lending for NRSE will be required to meet the development needs of the poorest countries.

SUMMARIES: CONSULTANT'S REPORTS ON DRAUGHT ANIMALS AND PEAT

Draught Animals and Peat, identified as part of the 14 NRSE within the scope of the Conference, were studied and reported upon by two Consultants. Following are their summaries.

DRAUGHT ANIMALS

Eighty-five to ninety percent of the populations of Asia and Africa depend on manual and draught power, while mechanization benefits merely 10-15%. Man and beast still share the energy burden in a mutually dependent symbiotic relationship. However, as the small farmer's main instrument of production, it is more fairly and evenly distributed than any other source of energy. Four hundred million draught animals in the developing countries, valued at $100 billion, make available 112 million kilowatts of power. Replacement of this power source would require $250 billion. On the other hand, modernization of draught animal power would improve the living standard of the small farmer.

The Report on Draught Animal Power examined the use of draught animals in farming and transport, and studied its economic and infrastructure aspects. The report concluded that improved equipment and implements for draught animals will contribute to increased crop yield at reduced cost, and substantially increase the total freight moved by animal energy in rural areas and even in some urban areas. Research and development are necessary to provide these improved implements. Studies of ways to ensure their widespread use must be undetaken once they are available.

With respect to economic considerations, the Report noted that the average cost of a draught animal is $200 whereas that of a tractor is $8,000 thus making animal much more within the range of the average farmer's budget. Since man power is currently the predominant energy source for farming in large areas of Africa and Asia, output can be significantly increased with the introduction of draught animals. When not being used for farm labour, animals can be used for transport and thereby providing the small farmer with an added source of income. Increased efficiency of draught animal power will allow increased employment opportunities in both rural and some urban areas.

The Report made several recommendations. The collection of data on draught animals should be initiated. Regional centres for draught animal power should be set up to collect information, conduct socio-economic studies, promote research and development and education and training, and facilitate the transfer of technology. Improved vehicle technologies and techniques for breeding and rearing of draught animals should be undertaken and propagated. Finally, the infrastructure to be developed for animal power should include: compiling statistics; establishing credit and insurance systems; organizing farmers; defining laws for working norms; and establishing training and extension activities, appropriate veterinary services, and the creation of Animal Energy Boards in countries having large populations of draught animals.

PEAT

Found in 40 to 50 countries on all continents, peat can offer a viable alternative to the scarcity of wood for home cooking purposes and can replace fuel sources in generating heat or power. The current fuel usage of peat in the world is equivalent to 25 million tonnes of oil. The three principal users are the Soviet Union, Ireland and Finland. Several other industrialized and developing countries have started their own peat programmes. The total global fuel peat resources are estimated to be 100,000 million tonnes of oil equivalent which is close to 50% of the known natural gas resources.

Conventional fuel peat products include milled peat, hand-cut peat, and sod peat (and their processed forms such as briquettes and pellets). Gasification and liquefaction of peat are undergoing research and development. Reduction of the moisture content is the most demanding task in fuel peat production. While the water content of peat exceeds 90% in its natural state, it can be reduced 10 to 55% depending on the production and processing method.

Peat is presently used in individual homes and on small and large scales with the plant sizes varying from a few kilowatts to 600 MW. The economic viability of peat as a fuel depends on such local conditions as available fuel alternatives, labour and material costs, transportation distances, climatic conditions and operation scale. The most serious constraints, especially in developing countries have been: lack of information on peat resources; peat as an energy alternative; and the absence of peat in the energy development programmes of international organizations.

The Report on Peat contains three principal recommendations. Developing countries, particularly those with unexploited peat resources, should estimate this resource; incorporate peat into their energy programmes and strengthen their capability to adapt peat technology to their needs; and promote international collaboration with peat-producing countries. Peat-producing countries should support developing countries through bilateral financial support and scientific and technical assistance in planning, research and training. International organizations, particularly the UN system with its relevant agencies and the international development banks, should include peat energy in their development and lending programmes.

For further information concerning the UN Conference and its preparations, please contact:
Information Officer, UN Conference on New and Renewable Sources of Energy
DESI/DPI - Room 1061-J, United Nations, New York, NY 10017, USA. Tel. (212) 754-6875

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amount. The massive capture of solar energy and its conversion into a stored product occurs world-wide with an efficiency of only 0.1%. The process occurs because of the adaptability of plants. It can be used over most parts of the earth.

333/81 OVERALL EFFICIENCIES FOR CONVERSION OF SOLAR ENERGY TO A CHEMICAL FUEL. Sandia Laboratory, Livermore, CA (USA). (From Proceedings of the Second Miami International Conference on Alternative Energy Sources, held Miami Beach, FL, USA, 10 Dec. 1979). SAND-79-8636 (1979) 22p. NTIS. US$7.50.

A complete and consistent scheme for determining the overall efficiency of a generalized process for the conversion of solar energy into a chemical fuel is developed and applied to seven conversion processes: conversion of concentrated sunlight to electricity in a conventional thermal cycle followed by hydrogen production via water electrolysis; thermochemical conversion with concentrated solar energy as the heat source; photovoltaic conversion to electricity followed by water electrolysis; direct photoelectrolysis of water; natural photosynthesis followed by pyrolysis or digestion of the biomass to convert it to a more convenient form; and direct photochemical production of hydrogen or some other chemical that is capable of undergoing exothermic conversion back to the starting material. It is demonstrated that the overall efficiency of each of these processes is determined by 10 common factors: maximum theoretical efficiency; inherent absorption losses; inherent internal losses; rate-limiting effects; reflection losses; transmission losses; coverage losses; system construction requirements; parasitic losses; and harvesting and conversion losses. Both state-of-the-art and optimistic values are assigned to each factor for each of the seven conversion processes. State-of-the-art overall efficiencies range from 5% for thermal conversion down to essentially zero for the undeveloped thermochemical and quantum processes. Optimistic values for overall efficiencies in the range of approximately 10 to 15% are calculated for several of the processes. Finally, candidate areas for research are identified by comparing state-of-the-art and limiting values for both the individual factors and the overall efficiencies.

C1. Biomass Production and Conversion

334/81 AN OVERVIEW OF BIO-ENERGY PROJECTS IN THE UNITED STATES. P.F. Bente, Jr. (Bio-Energy Council, 1625 Eye Street, NW, Washington, DC 20006 (USA)). Solar Energy, vol. 25, p. 397-400 (1980).

This article reviews the projects undertaken in the USA on the use of the solar energy stored in plant matter via photosynthesis including various biofuels, biomass and the energy obtained directly by burning biomass. The author points out that the energy represented by the total standing biomass is equivalent to about 25 times the total amount of energy used from all sources each year, with 90% of this in forests. Contrary to common opinion, US forest resources are producing timber at a rate of growth that is nearly twice that of all timber harvested for either wood products or energy. The programmes examined cover the direct use of wood for energy, other biomass resources for energy, techniques for burning or gasifying woody biomass and fuel-alcohol production from carbohydrate and cellulosic materials. The author concludes with an examination of the environmental considerations. 3 refs.

335/81 FUEL FROM PLANTS. M. Calvin (University of California, Berkeley, CA (USA)). SciQuest, vol. 52, no. 6, p. 16-9 (July 1979).

The author's idea of growing petroleum, or a petroleum substitute, required imaginative experiments and post-World War II technology in order to gain an understanding of photosynthesis. Some plants go beyond sugar production and fermentation and produce hydrocarbons similar to petroleum, except for the extra length of the molecule of carbon and hydrogen. Later emulsions are produced by many species, but the gopher plant Euphorbia lathyrus has been chosen for the experiments.

336/81 HIGHER PLANTS AS POSSIBLE SOURCES OF PETROLEUM SUBSTITUTES. S.G. Coffey and G.M. Halloran (School of Agriculture and Forestry, University of Melbourne, Parkville, Victoria 3052 (Australia)). Search, vol. 10, p. 423-8 (1979).

Potential plants species cable of providing hydrocarbons and seed grains as substitute sources for the production of fuels and chemicals now provided by petroleum are examined. The possibilities of improving the efficiency and chemical composition through management and genetics are considered. 48 refs.

337/81 PLANTATIONS PRODUCING HYDROCARBONS. Nishimura H. (Department of Agricultural Chemistry, Hokkaido University, Sapporo (Japan)). Journal of the Fuel Society of Japan (Nenryō Kyōkai Shi), vol. 59, no. 3, p. 171-81 (1980). In Japanese.

This article examines the chemicals produced by Hevea brasiliensis and several species of Euphorbia and Eucalyptus. 9 refs.

338/81 NET ENERGY ANALYSIS OF ALCOHOL PRODUCTION FROM SUGARCANE. C.S. Hopkinson, Jr. and J.W.

Day, Jr. (Louisiana State University, Baton Rouge, LA (USA)). Science, vol. 207, p. 302-4 (18 Jan. 1980).

Energy requirements were calculated for the agricultural and the industrial phase of ethyl-alcohol production from sugarcane grown in Louisiana. Agricultural-energy requirements comprised 54% of all energy inputs, with machinery, fuel, and nitrogen fertilizer representing most of the energy subsidies. Overall net energy benefits (output:input) for alcohol production ranged from 1.8:1 to 0.9:1, depending on whether crop residues or fossil fuels were used for industrial processes.

339/81 BIOMASS FROM MARINE MACROSCOPIC PLANTS. W.J. North (W.M. Keck Engineering Laboratories, California Institute of Technology, Pasadena, CA 91125 (USA)). Solar Energy, vol. 25, p. 387-95 (1980).

Marine-biomass production has several attractive features, the chief one being the large areas of ocean available for such activities. Disadvantages include the meager state of existing knowledge and the difficulties of operating under oceanic conditions. Algae have been farmed by Asians for many years in estuaries and along coasts, but the techniques involved are frequently highly labour-intensive. Seaweeds tend to be low in cellulose and lignin (chemically refractile compounds common in terrestrial plants) but are typically high in water and salt contents. Because of the water content, bacterial digestive techniques seem favoured for purposes of fuel production. Active research fields include primarily biological and engineering studies of biomass-production systems, as well as investigations of fuel-conversion processes and economics of proposed systems. Investigations of Woods Hole Oceanographic Institution have involved screening species to identify the highest producers, factors influencing productivity, and special studies such as the efficiency with which nitrogen can be recycled within the culturing system. Investigations at the California Institute of Technology have emphasized culturing of a single, very large species, giant kelp. Efforts were made to identify the principal problems involved in growing plants in oceanic settings. Economic studies by three organizations have dealt primarily with feasibility of oceanic as opposed to coastal farming systems. 22 refs.

340/81 WOODFUEL: A TIME FOR RE-ASSESSMENT. K. Openshaw (University of Dar-es-Salaam, Dar-es-Salaam (Tanzania)). National Resource Forum, vol. 3, no. 1, p. 35-51 (Oct. 1978).

Official statistics and surveys show that wood fuel is the dominant end use of forest products, especially in developing countries. This paper examines the end-use pattern and per-capita consumption figures for selected developing countries. In terms of total energy requirements, wood fuel (a renewable resource) is the third most important fuel after oil and coal, but may be the primary fuel in terms of number of actual consumers. The future consumption pattern is estimated for the industrially developing and developed countries and it is anticipated that total wood-fuel consumption may increase by about 2% per year at least until the year 2000. The supply position shows that while present consumption of all forest products is more or less in balance with the increment of the growing stock, in certain areas, the forest capital is being depleted to meet demand. Total demand is likely to double by the turn of the century. Therefore, plantations, especially of fuel wood, will have to be established if the growing stock is not to be depleted and if an energy crisis in developing countries is to be averted. 12 refs.

341/81 A CHARCOAL STOVE FROM SRI LANKA. D. de Silva (Division of Wood and Cellulose Technology, Ceylon Institute of Scientific and Industrial Research, P.O. Box 787, Colombo 7 (Sri Lanka)). Appropriate Technology, vol. 7, no. 4, p. 22-4 (1981).

The author notes that while charcoal is not widely used as a domestic cooking fuel in Sri Lanka, it is the wish of government authorities to introduce charcoal from fuelwood plantations for this purpose in urban areas as a substitute for, or supplement to, the use of kerosene and firewood. The prototype stove described was designed specifically for this programme. It consists of a clay cylinder with a narrow waist and a 50-cm^2 side opening at the base, rests on a clay pan and has a removable convex clay grate held inside the clay cylinder at a position 12 cm from the top. There is no provision for heat regulation and no method for extinction before the full charge of charcoal is burnt out. A 30% efficiency was achieved, although heat losses could be further reduced by insulating the sides and base. 4 refs.

C2. BIOGAS PRODUCTION AND UTILIZATION

342/81 BIOGAS TECHNOLOGY AND UTILISATION - A STATUS REPORT. Department of Science and Technology, Government of India (New Delhi, (India)). Department of Science and Technology, Government of India, New Delhi, India (1981) 94p.

This report describes the energy situation in India with attention to both urban and rural sectors. Focusing on the rural sectors, it is noted that much progress has been and can be made using biogas technology. The activities of 13 institutions in India in the field of biogas research and utilization have been compiled. It is seen that the installation of a large number of biogas plants in India would be able to contribute to the solution of present energy prices to a considerable extent and provide a decentralized cheap source of energy. Detailed drawings of the Khadi and Village Industries Commission and Janata designs are included.

343/81 DEMONSTRATION OF ANAEROBIC BIOGAS DIGESTERS IN DEVELOPING COUNTRIES. PART III. THE PHILIPPINES. M.H. Simpson and E.C. Morales, Journal of Environmental Science, vol. 23, no. 2, p. 20-4 (1980).

The main theme of this series of articles is that ours is now a world-wide society, short on meeting needs for energy yet long on waste from our industrial, agricultural and human consumption processes. This is a study report about development in the Philippines where waste management has been recognized and considered as an important practical source of energy. This is revealed by several reports of the number of biogas plants in operation in this country. According to the July 31, 1977 survey made by the Philippines Bureau of Animal Industries, 200 biogas plants were then installed and in operation, of which 46 were government-owned and 154 privately-owned. More have been installed since then. This report presents some of the operating observations and developments from the joint engineering-analyses project of the Philippines Bureau of Animal Industry, Man and the Biosphere Inter-Agency Committee on Ecological Studies, Bureau of Fisheries and Aquatic Resources and the National Institute of Science and Technology. The project's main objective was to show that establishing a biogas plant involves not only the production of a methane-gas mixture but the integration of its other products as part of a system (i.e., using effluent water from the biogas digester for production of algae chlorell sp. for livestock and poultry feed, production of fish and fertilizing irrigating of pasture and vegetable plots). Housing-development sewer systems with added biogas generators are also discussed.

344/81 ENERGY CONSERVATION AND PRODUCTION IN A PACKED-BED ANAEROBIC BIOREACTOR. W.W. Pit, Jr. and R.K. Genung (Oak Ridge National Laboratory, Oak Ridge, TN (USA)). (From Proceedings of the Fourth Symposium on Energy from Biomass and Wastes, held Lake Buena Vista, FL, USA, 21 Jan. 1980). CONF-800129-4 (1980) 39p. NTIS. US$8.50.

Oak Ridge National Laboratory (ORNL) is developing an energy-conserving and producing waste-water treatment system based on a fixed-film anaerobic bioreactor. The treatment process is based on passing waste water upward through the bioreactor for continuous treatment by gravitational settling, biophysical filtration and biological decomposition. A two-year pilot-plant project using a bioreactor designed to treat 19,000 liters per day has been conducted using raw waste water on a municipal site in Oak Ridge, Tennessee, USA. Data obtained for the performance of the bioreactor during this project have been analysed by ORNL and Associated Water and Air Resources Engineers (AWARE), Inc. of Nashville, Tennessee, USA. From these analyses it was estimated that hydraulic-loading rates of 0.08 liters per minute per m^2 and hydraulic-residence times of 10 hours could be used in designing such bioreactors for the secondary treatment of municipal waste water. Conceptual designs for total-treatment systems processing up to four million liters of waste water per day were developed based on the performance of the pilot plant bioreactor. These systems were compared to activated sludge-trreatment systems also operating under secondary treatment requirements and were found to consume as little as 30% of the energy required by the activated sludge systems. Economic advantages of the process result from the elimination of operating energy requirements associated with the aeration of aerobic-based processes and with the significant decrease of sludge handling costs required with conventional activated sludge treatment systems. Furthermore, methane produced by anaerobic-fermentation processes occurring during the biological decomposition of carbonaceous wastes also represented a significant and recoverable energy production. For dilute municipal waste water this would completely offset the remaining energy required for treatment, while for concentrated industrial waste water would result in a net production of energy.

345/81 METHANE PRODUCTION FROM ANIMAL WASTES AND ITS PROSPECTS IN JAPAN. Haga K., Tanaka H. and Higaki S. (National Institute of Animal Husbandry, Ministry of Agriculture and Forestry, Chiba-shi 280 (Japan)). Agricultural Wastes, vol. 1, no. 1, p. 45-55 (1979). In Japanese.

Basic experiments using a 200-liter digester for pig slurry are described, together with 6 ongoing projects using different digester designs for methane and fertilizer production from pig, poultry and cattle slurry. Maximum Japanese biogas production is estimated to be 1.68×10^9 m^3/y, which could supply gas to 2 million families, and is equivalent to 1.01×10^6 kl/y of petrol (about 18% of all petrol used in agriculture). 4 refs.

346/81 CONTINUOUS ORGANIC WASTE DIGESTER AND METHANE GAS GENERATOR. V.A. Araneta (Dapitan Street, Metro Manila (Philippines)). Technology Journal, vol. IV, no. 3, p. 58061 (1979).

This article describes a patent on the construction of a utility model of an industrial product of a continuous organic-waste digester and methane-gas generator. It comprises of an airtight chamber to receive slurry of organic waste; a gas-water scrubber to purge carbon dioxide, odor-omitting gases and froth or scrum from newly formed methane gas evolving from said slurry of organic wastes; and two dually functioning slurry-feed and -discharge pipes connected to a reversible pump. It has one pipe with an opening at the base of an airtight chamber and the other pipe with up-ended openings below the fluid level of the slurry to be accumulated in the airtight chamber.

347/81 METHANE ON THE MOVE. A DISCUSSION OF SMALL ANAEROBIC DIGESTERS. FINAL REPORT. S. Schellenbach, W. Turnacliff, F. Varani, J.L. Burford, Jr. and S.B. Don (Colorado Energy Research Institute, Golden, CO (USA)). PB-296542 (Mar. 1977) 101p. NTIS. US$9.00.

This report is on small anaerobic-digestion units, stimulated by experiments operated by Bio-Gas of Colorado. A grant from the Four Corners Regional Commission to the Colorado Energy Research Institute enabled Bio-Gas to build a 12- to 50-cow digestion unit on a trailer which could be pulled by a tractor to 19 different demonstration sites in Colorado, New Mexico, Arizona, Utah and Nevada, USA. During this same period, Bio-Gas conducted laboratory experiments to determine yield coefficients of different manures and defined parameters to evaluate the economic feasibility of building digesters on a small or self-sufficiency scale. First the report describes the mobile digestion unit of 22,000 liters with its start-up phases, operation, production and problems. Secondly, a discussion of the tour and a summary of the journal in the appendix tell how the digester performed and how it was received among the people who came to see the demonstration. Finally, the report includes designs for four different sizes of digesters based on data collected from the mobile unit, the tour and the laboratory. A series of design tables which let interested persons easily size a digestion system and tailor it to their specific needs are included. The tables estimate gas production from a variety of manures and system sizes so the economics of the system can be studied.

348/81 MANUFACTURE OF METHANE FROM WASTES. Japan Patent 1976-159,023 (21 July 1978). File date: 29 Dec. 1976. 6p. In Japanese.

Waste materials such as swampland sludge, night soil, and vegetable wastes are mixed with an approximately 10% pyroligneous acid solution in a mixing tank, kept in it for a certain period, charged into a CH_4 generation tank equipped with agitators, optionally mixed with the pyroligneous acid solution and stirred to obtain CH_4.

D. WIND ENERGY

349/81 WIND POWER. D.G. Shepherd (Cornell University, Ithaca, NY (USA)). Advances in Energy Systems and Technology, vol. 1, p. 1-124. P. Auer (ed.), Academic Press, New York, NY, USA (1978).

A background on wind power is presented in an introductory section. The subjects covered in additional sections are: energy, power, and momentum considerations (energy available, performance boundaries); turbine types and terminology; aerodynamics of wind turbines (flow through a rotor, aerodynamic analysis of propeller type and cross-wind axis type rotors); wind-energy concentrators and augmentors; wind characteristics and siting; environmental considerations; structural considerations; testing and test procedures; applications and systems; economics of wind power; state-of-the-art; and wind and weather. 63 refs.

350/81 VERTICAL AXIS WINDMILL AND WIND COLLECTOR. S.D. Verma (Gujarat University, Ahmedabad (India)). P. 560-3 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

A vertical-axis windmill was designed in combination with a wind-collector amplifier. The collector had a large entrance cross-section and a small exit port. This way wind speed was increased and the needed size of the paddles was decreased. The vertical shaft of the windmill was connected with a DC car generator via a step-up oil-filled gear with a gear ratio of 1:16. A working model of the windmill, collector-amplifier and DC generator system was fabricated, tested and found to work for wind speeds >24 km/h.

351/81 THE AERODYNAMIC DESIGN AND TESTING OF A VERTICAL AXIS WINDMILL. A.C. Willmer (Aircraft Group, British Aerospace, Bristol (UK)). P. 286-9 of Future Energy Concepts (IEE Conference Publication No. 171). IEE London, UK (1979).

The design of a twin-bladed, untwisted, vertical-axis wind turbine (of H form) was evaluated using a model (3-m diameter) with blades 2-m long. The results of the tests are presented graphically and extrapolated for turbines of 25 and 75 m diameter. 9 refs.

352/81 FREE WATER SUPPLY FROM WIND POWER. H. Frees (Windpumpen-Zentrale, Eckernförde (Fed. Rep. of Germany)). P. 345-51 of Energie vom Wind (Proceedings of the Conference on Wind Power with Exhibition, held Bremen, Fed. Rep. of Germany, 7-8 June 1977). U. Bossel (ed.), Deutsche Gesellschaft für Sonnenenergie eV, Munchen, Fed. Rep. of Germany (1977). In German.

Pumps driven by wind power and used for draining soil or for irrigating economically used areas are described.

353/81 WIND POWER (CITATIONS FROM THE NTIS DATA BASE). REPORT FOR 1964-APR. 1977. A.S. Hundemann (National Technical Information Service, Springfield, VA (USA)). NTIS/PS-77-0399 (June 1977) 258p. NTIS. US$32.50.

The feasibility, use, and engineering aspects of wind power and windmills are discussed in these citations of US-government funded research reports. Abstracts primarily cover the use of wind power for electric-power generation and wind-turbine design and performance. General studies dealing with comparative analyses of wind power and alternative-energy sources are included, as are energy-storage devices which can be used in these systems. This updated bibliography contains 253 abstracts, 101 of which are new entries to the previous edition.

354/81 WIND POWER. VOLUME 2. 1977-APRIL 1979 (CITATIONS FROM THE NTIS DATA BASE). REPORT FOR 1977-APRIL 1979. A.S. Hundemann (National Technical Information Service, Springfield, VA (USA)). NTIS/PS-79-0534 (June 1979) 282p. NTIS. US$32.50.

The feasibility, use, and engineering aspects of wind power and windmills are discussed in these citations of US-government funded research reports. Abstracts primarily cover the use of wind power for electric-power generation and wind-turbine design and performance. General studies dealing with comparative analyses of wind-power and alternative-energy sources are included, as are energy-storage devices which can be used in these systems. This updated bibliography contains 276 abstracts, 123 of which are new entries to the previous edition.

E. ENERGY STORAGE

355/81 COMPARISON BETWEEN THE PERFORMANCE OF THREE DIFFERENT METHODS FOR STORAGE OF LOW TEMPERATURE HEAT (SOLAR HEAT) FOR SPACE HEATING. H. Hedman, H. Zinko and J.E. Nowacki (Styrelsen för Teknisk Utveckling, Stockholm (Sweden)).

The following systems were studied: a solar pond with a hot-water heating system, airborne heating systems with heat storage in a rock bed or as latent heat in salt hydrates. In the cost estimates, a typical system with 30-m^2 solar collectors and storage need of about 100 kWh was used. The airborne systems were found to be cheaper than the waterborne, and latent-heat storage cheaper than rock-bed storage.

356/81 ELECTROCHEMICAL STORAGE OF PHOTOVOLTAIC SOLAR ENERGY. H. Saha (University of Kalyani, Kalyani (India)). Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

Electrochemical storage of solar energy by a suitable storage battery is an integral part of the solar-cell power system for terrestrial applications. Important characteristics of storage batteries for this application are briefly reviewed. A comparative analysis is then made for the different types of batteries which may be used for this purpose. A design procedure is next developed for the choice of the correct capacity of the battery for any terrestrial application. Results of the field trial of a solar-power system using a lead-acid battery specially developed for this purpose are then reported. Finally, the potential applications of such solar-cell power systems in India are briefly reviewed.

357/81 HEAT STORAGE IN BUILDINGS: AN OVERVIEW. B. Givoni (Ben-Gurion University, Beersheba (Israel)). P. 559-72 of the Conference on Heat and Mass Transfer in Buildings (held Dubrovnik, Yugoslavia, 29 Aug. 1977). Hemisphere Publishing Corp., Washington, DC, USA.

Methods of heat storage in buildings and their effect on thermal performance, comfort, and energy consumption of air conditioned and non-conditioned buildings are discussed. The role of heat storage in buildings heated and cooled by solar and other renewable natural energies is analysed in relation to different types of buildings.

358/81 ENERGY STORAGE FOR SOLAR AIR CONDITIONING APPLICATIONS UTILIZING A FORM-STABLE, HIGH DENSITY POLYETHYLENE PELLET BED. R.B. Whitaker, G.H. Jenkins, G.L. Ball and I.O. Salyer (Monsanto Research Corp., Dayton, OH (USA)). P. 581-92 of Proceedings of Solar Energy Storage Options Workshop (held San Antonio, TX, USA, 18 Mar. 1979). 1979. NTIS. US$41.00 for complete proceedings (CONF-790328-P1 and P2).

A phase-change thermal-energy storage (TES) bed material, consisting of form-stable, crystalline, high-density polyethylene (HDPE) was developed by Monsanto Research Corporation (MRC), and its utility demonstrated. High-density polyethylene is a low-cost, commercial plastic that is produced in the US on a multibillion kg/y scale. HDPE has a high latent heat of fusion value (nearly 50 cal/g), which is essential for it to be useful in thermal-energy storage applications. Of considerable importance for solar cooling, the crystalline melting point and freezing point of HDPE are in the 120 to 140 °C temperature range most suited for solar absorption air conditioning applications.

Furthermore, it is insoluble in common heat transfer liquids, such as water and ethylene glycol. The key in the development of HDPE as a useful TES material was to retain its high heat of fusion value, while making it dimensionally stable when melted. This was done by a controlled, limited crosslinking (by either chemical or radiation crosslinking) of the polymer chains, thus restricting their mobility to such an extent that the polymer would not flow in the melt. The results obtained from a cost-effectiveness comparison of three different methods of crosslinking HDPE to make it a form-stable, useful TES material are presented. In addition, the projected costs of a proposed HDPE-liquid thermal transfer system are compared to those of other liquid and air thermal transfer TES systems operative in the same 100 to 150 °C range.

359/81 PHASE CHANGE THERMAL STORAGE FOR A SOLAR TOTAL ENERGY SYSTEM. R.E. Rice and E.M. Cohen (Comstock and Wescott, Inc., Cambridge, MA (USA)). Vol. 1, p. 511-5 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress (held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press, Elmsford, NY, USA (1978).

An analytical and experimental programme is being conducted on a one-tenth scale model of a high temperature (584 °K) phase-change thermal energy-storage system for installation in the Solar Total Energy Test Facility of the Sandia Laboratories at Albuquerque, New Mexico, USA. The thermal-storage medium is anhydrous sodium hydroxide with 8% sodium nitrate. The programme will produce data on the dynamic response of the system to repeated cycles of charging and discharging simulating those of the test facility. Data will be correlated with a mathematical model which will then be used in the design of the full-scale system.

F. SOCIO-ECONOMIC ASPECTS

360/81 PATTERNS OF ENERGY CONSUMPTION AMONG THE URBAN AND RURAL POOR IN DEVELOPING COUNTRIES (PATRONES DE CONSUMO ENERGETICO DE LOS HABITANTES POBRES, RURALES Y URBANOS EN LOS PAISES EN DESARROLLO). J. Dunkerley (Resources for the Future, 1755 Massachusetts Av., N.W. Washington, DC (USA)). P. 139-56 of Caribbean Consultation on Energy and Agriculture (Consulta del Caribe sobre Energía y Agricultura). Instituto Superior de Agricultura, Santiago, Chile (1980).

There is little systematic information available on the level and quality of energy sources at present being delivered to the poor of the developing world. Furthermore, there has been little analytic study on how rapidly the energy consumption of the poor will rise in the future. Rising consumption could take the form of commercial fuels, especially imported oil, thus aggravating balance of payments problems, and intensifying inflationary pressures. Alternatively, increases in consumption might put renewed pressure on dwindling traditional sources of energy such as fuelwood. Knowledge of energy consumption patterns is therefore important not only in relation to the provision of basic services to the poor but also to develop strategy and policy. The paper surveys the information available on the household-energy consumption of the poor in developing areas, and draws some preliminary conclusions about the effects of higher incomes on consumption. From the admittedly patchy data available, it appears that household-energy consumption, measured in heat equivalent, rises by less than rises in income, largely due to the move to more thermally efficient (commercial) fuels at higher levels of income.

Existe poca información sistemática sobre el nivel y la calidad de las fuentes de energía que utilizan las personas indigentes de los países en desarrollo. Además, escasean los estudios analíticos sobre la velocidad con que aumentará en el futuro el consumo de energía entre los pobres. Los aumentos en el consumo representarán incrementos en la demanda de combustibles comerciales, especialmente para la importación de petróleo, agravando así los problemas de la balanza de pagos e intensificando las presiones inflacionarias. Por otra parte, un mayor consumo podría aumentar la presión sobre fuentes energéticas tradicionales en merma, como lo es la leña. Es necesario conocer mejor los patrones de consumo energético, no sólo para la provisión de servicios básicos a los pobres, sino también para el diseño de las estrategias y políticas de desarrollo. Esta ponencia analiza la información disponible sobre el consumo familiar energético de las personas indigentes de las regiones en desarrollo y expone algunas conclusiones preliminares acerca del efecto de los aumentos del ingreso sobre el consumo. Los datos disponibles, reconocidamente incompletos, parecen indicar que el consumo familiar de energía, medido en equivalentes calor, no aumenta proporcionalmente con el ingreso, debido a que a niveles de ingreso más altos se utilizan combustibles (comerciales) de mayor eficiencia térmica.

361/81 SOCIAL FORESTRY IN INDIA. M.M. Pant (Forest Research Institute and Colleges, Dehra Dun (India)). Unasylva, vol. 31, no. 125, p. 19-24 (1979).

This article describes the concept, needs and efforts in social forestry in India. Social forestry is seen to be the production of trees over scattered lands wherever tree growing is possible. Such farm forestry aims at tree culture in association with agriculture and can provide relief for farmers by enabling them to be self-sufficient in firewood, small timber and fodder. Additional benefits include the possibility of selling extra firewood, achieving soil stability and conserving water. The author points out that much work has been done in this area in Haryana, Gujarat, Tamil Nadu, Rajasthan, Punjab and Uttar Pradesh. It is noted that one hectare of plantation activity can generate 150-500 man-days of employment during the first 3 years, thereby contributing to alleviating problems of unemployment. 13 refs.

362/81 ASSESSING SOLAR PHOTOVOLTAIC ENERGY SYSTEMS FOR CROP IRRIGATION. R.W. Matlin and M.T. Katzman (Massachusetts Institute of Technology, Cambridge, MA (USA)). Water Resources Bulletin, vol. 15, p. 1308-17 (1979).

An economic analysis of the profitability of adopting solar photovoltaic-energy systems for crop irrigation is undertaken. The economic, technological, and political uncertainties surrounding adoption are discussed with reference to their impact on anticipated profitability. A field test in Nebraska, USA, is described. 10 refs.

363/81 COST CONTROL FACTORS IN THE PRODUCTION OF ETHANOL FROM SUGAR CANE. F.H.C. Kelly (Department of Industrial Chemistry, Universiti Sains Malaysia, Minden Pulau, Penang (Malaysia)). International Sugar Journal, vol. 82, p. 172-7 (1980).

This article reviews the different factors which effect the cost of ethanol produced from sugar cane. Predictions for the minimum cost in 1985 are included.

SELECTED ARTICLE

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HIGH EFFICIENCY 1.43 AND 1.69 eV BAND GAP $Ga_{1-x}Al_xAs$-GaAs SOLAR CELLS FOR MULTICOLOUR APPLICATIONS

by

E. Fanetti, C. Flores, G. Guarini, F. Paletta and D. Passoni
Centro Informazioni Studi Esperienze SpA, Segrate, Milan, Italy

SUMMARY

In this paper the fabrication and the most significant characteristics of 1.43- and 1.69-eV band-gap $Ga_{1-x}Al_xAs$-GaAs solar cells, designed for high efficiency and high-concentration systems, are described. These cells are characterized by a very low series resistance obtained by using beryllium as a p-type dopant and by using a simplified structure including a minimum number of layers grown by liquid-phase epitaxy.

Conversion efficiencies up to 21% and 19.2% were measured at 210 suns, air mass 1.5, for the low-gap and high-gap cells respectively, while 20% and 18% efficiencies were observed at 1000 suns. For the higher band-gap cell a conversion efficiency of 14.2% was also measured at 2500 suns. The overall conversion efficiency of some multicolour systems utilizing these $Ga_{1-x}Al_xAs$-GaAs cells, combined with spectrum-splitting optical filters and with a lower band-gap (1.1 eV) cell, were also estimated under realistic assumptions.

1. INTRODUCTION

It has already been demonstrated that multigap solar-cell systems can achieve conversion efficiencies of approximately 30% for a two-cell combination, while a 35% theoretical efficiency may be expected for three cells. Following the theoretical analyses of several researchers [1, 2], 1.69-1.1 eV and 1.69-1.43 eV represent two very efficient band-gap combinations, corresponding to $Ga_{0.8}Al_{0.2}As$(1.69 eV), GaAs(1.43 eV) and silicon(1.1 eV) solar cells [3]. Even if the first pair may be considered as very close to the optimum, experimental conversion efficiencies higher than 25% can also be expected for the second one, including the optical losses of a spectrum-splitting filter which reflects and transmits sunlight separately onto the two cells. Similarly, for a three-cell system composed of silicon(1.1 eV), GaAs(1.43 eV) and $Ga_{0.63}Al_{0.37}As$(1.92 eV) cells, an overall conversion efficiency higher than 30% can be realistically expected.

Experimental evidence of high-efficiency operation has already been given for the Si(1.1 eV)-$Ga_{0.83}Al_{0.17}As$(1.65 eV) system with a spectrum-splitting filter. An overall efficiency of 27% at 113 suns and 26% at 489 suns has been measured [4].

The spectrum-splitting method, however, introduces additional high-cost components such as the optical filter and also requires critical and expensive mounting operations. Multigap systems can also be obtained using monolithic structures which promise higher efficiencies and lower assembly costs but require very sophisticated material technologies, and no high-efficiency experimental results have been given so far.

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A first $Ga_{0.80}Al_{0.20}As$ solar cell has already been grown by liquid-phase epitaxy (LPE) on top of a GaAs cell in a monolithic structure [5]. The observed efficiency was not higher than 10-15%. However, GaAs and $Ga_{1-x}Al_xAs$ solar-cell technology must be considered very promising for multigap applications in the form of both spectrum-splitting or monolithic-cell systems. The major drawbacks of actual LPE $Ga_{1-x}Al_xAs$ technology are very high cell costs and very low production capability. Costs can be drastically reduced by high-efficiency high-concentration performances and production capability can be substantially increased by multiwafer LPE processes [6] and by simplified solar-cell structures.

In the present paper, the fabrication technique of 1.43- and 1.69-eV band-gap $Ga_{1-x}Al_xAs$-GaAs solar cells designed for high-efficiency high-concentration operation is described. The LPE growth process was simplified by using a minimum number of epitaxial layers: one for the low band-gap cell and two for the high band-gap cell.

The series resistance was reduced to a typical value of about 10 mΩ cm^2 by use of beryllium as a p-type dopant instead of the commonly used zinc.

The most significant characteristics, such as conversion efficiency and fill factor, are reported as functions of the concentration ratio. Preliminary life tests were also started with very encouraging results.

The concentration performances of multigap systems using the cells described in this paper in combination with other possible cells and spectrum-splitting filters were also calculated under realistic assumptions.

2. MATERIAL PROPERTIES

The LPE technique adopted for material preparation has already been described in a previous paper [7]. The 1.69-eV band-gap cell structure shown in Fig. 1(a) includes only two epitaxial layers: a $Ga_{0.80}Al_{0.20}As$ tin-doped n-type layer and a $Ga_{0.10}Al_{0.90}As$ beryllium-doped p-type layer. The p-type active region is obtained by the diffusion of beryllium during the epitaxial growth. The junction depth was adjusted by varying the growth time of the window layer. If compared with the three-epitaxial-layer structure of other $Ga_{1-x}Al_xAs$ cells [1, 4], the configuration proposed allows a simplified and more reproducible LPE growth process.

In the lower band-gap cell structure shown in Fig. 1(b), only one $Ga_{0.1}Al_{0.9}As$ p-type layer was grown directly on good quality substrates. Beryllium was chosen as the p-type dopant owing to its better characteristics compared with zinc [8].

(i) Beryllium vapour pressure is much smaller so that contamination of the LPE reactor is significantly reduced and better process control can be achieved.

(ii) For the same molar fraction in the solution, beryllium in GaAs and $Ga_{1-x}Al_xAs$ gives results one order of magnitude higher than for zinc, so that much lower sheet resistances can be obtained.

Two 2 cm by 2 cm wafers were processed simultaneously for each run. The minority-carrier diffusion lengths, measured by the electron-beam induced-current (EBIC) technique, are reported in Table 1.

TABLE 1

Minority carrier diffusion lengths measured by EBIC and by fitting (last column)

Type of cell	Substrate L_p (μm)	Window layer L_n (μm)	$Ga_{0.8}Al_{0.2}As$ layer L_p (μm)	Active layer L_n (μm)
1.43 eV	0.7-1.9	0.9	—	3.0
1.69 eV	—	0.9	1.1	2.5

For commercial substrates the minority-carrier diffusion lengths ranged from 0.7 μm for bad substrates to 1.9 μm for good ones. The diffusion lengths in the p-type active layers could not be evaluated easily by the EBIC method because the layers were too thin, but from comparison between calculated and experimental short-circuit current values, typical diffusion lengths of 1.5 and 3.0 μm were estimated for the higher and lower band-gap cells, respectively.

These data indicate that the basic properties of the $Ga_{1-x}Al_xAs$ layer for $x < 0.2$ are not very different from those of usual GaAs layers and that $Ga_{1-x}Al_xAs$ growth may already be considered a well established technological step.

3. CELL STRUCTURES AND FABRICATION PROCESS

As shown in Fig. 1, in both cells the contact grid touches the active layer through grooves selectively etched in the window layer by a solution of potassium iodide plus iodine. In this way low contact resistance is obtained even without any auxiliary p$^+$-GaAs

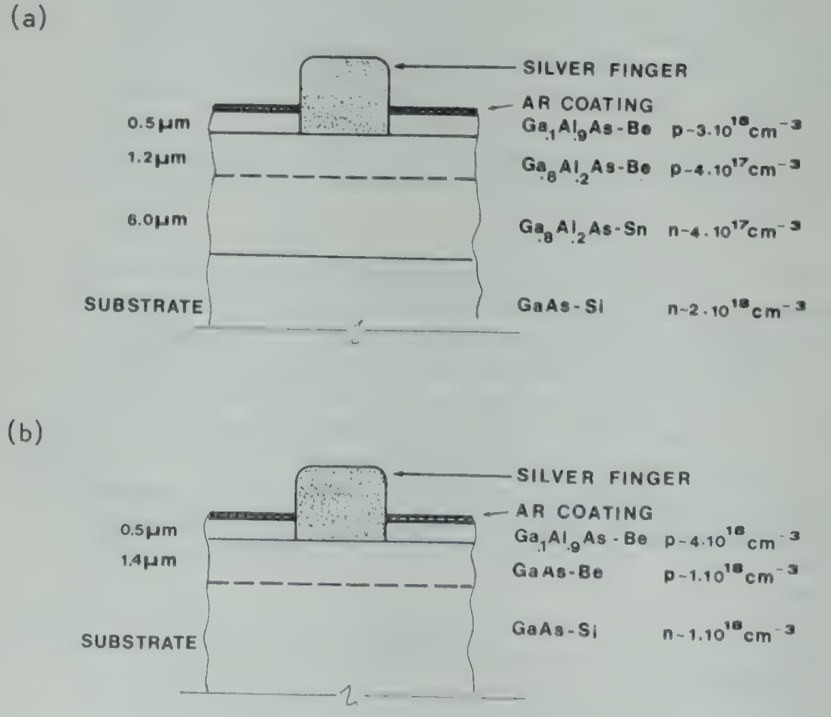
(a)
SILVER FINGER
AR COATING
0.5µm
1.2µm
6.0µm
SUBSTRATE
Ga$_{.1}$Al$_{.9}$As-Be p-3.10^{18}cm^{-3}
Ga$_{.8}$Al$_{.2}$As-Be p-4.10^{17}cm^{-3}
Ga$_{.8}$Al$_{.2}$As-Sn n-4.10^{17}cm^{-3}
GaAs-Si n-2.10^{18}cm^{-3}
(b)
SILVER FINGER
AR COATING
0.5µm
1.4µm
SUBSTRATE
Ga$_{.1}$Al$_{.9}$As-Be p-4.10^{18}cm^{-3}
GaAs-Be p-1.10^{18}cm^{-3}
GaAs-Si n-1.10^{18}cm^{-3}

Fig. 1 Solar cell cross sections:
(a) $Ga_{0.80}Al_{0.20}As$ cell structure;
(b) GaAs cell structure

top layer. A typical contact resistance of 10^{-4} Ωcm^2 was measured for both types of cell.

The grid configuration was the same as reported elsewhere [7]. The exposed area was 0.36 cm^2. Silver was then electrolytically grown on the grid fingers up to a thickness of 4 μm and a single layer of SiO antireflection (AR) coating was deposited by an electron-gun evaporator.

The cells were finally insulated through an Al_2O_3 layer and mounted on a copper heat sink. The total specific thermal resistance was found to be as low as 0.2 °C cm^2 W^{-1}. An additional layer of Sylgard 184 silicone-resin sealant was spun on the surface of the cell with the aim of protecting against ambient corrosion effects.

4. CELL EVALUATION

For 1.69-eV band-gap cells a first visual inspection was performed by observing the red-light emission under forward polarization. In this way non-uniform or dark regions due to the presence of growth defects or to bad adhesion of the grid fingers could easily be evidenced. This type of analysis has been useful, particularly during the development of the spray-etching technique for the ohmic contacts.

Some typical parameters of the dark current-voltage (I-V) characteristics measured for the two cells are reported in Table 2.

In Fig. 2 the quantum efficiencies measured as a function of wavelength are shown. The high wavelength cuts are typical of 1.69- and 1.43-eV band gaps and the shallow slopes on the short-wavelength side are due both to recombination in the window layers and to an increase in AR coating reflectivity in this spectral region.

In Fig. 3 the short-circuit current density calculated for the high band-gap cell as a function of the junction depth is reported for various values of minority-carrier diffusion length in the active layer. In order to calculate these curves, the $Ga_{1-x}Al_xAs$ absorption coefficients were derived from the literature [9]. As already noted, from the comparison between experimental and calculated values of Fig. 3, a typical value of 2.5 μm was derived for L_n in the active layer. In a similar way a 3-μm value was estimated for L_n in the active layer of 1.43-eV band-gap cells.

The electrical characteristics of the cells were measured both with an ORIEL sun-simulator lamp (up to a concentration ratio of 220 suns) and with natural light and Fresnel lenses (up to 2500 suns). The best results are reported in Table 3, for a concentration of 210 suns, air mass 1.5 (AM1.5).

Experimental conversion efficiencies are reported in Fig. 4 as a function of the concentration ratio. Because of a lower series resistance, a higher value of minority-carrier diffusion length and a better utilization of the solar spectrum in the low-energy region, the low band-gap cell showed a higher conversion efficiency for all the concentration ratios. The fill factor of the 1.69-eV solar cell had a maximum value of 0.86 at 200 suns which decreased to 0.82

TABLE 2. Measured parameters for I-V curves

Characteristics	1.43 eV cell	1.69 eV cell
Generation-recombination current (A cm^{-2})	10^{-10}	10^{-10}
Ideality factor	2.2	2.3
Injection current (A cm^{-2})	7×10^{-17}	1×10^{-18}
Ideality factor	1.1	1.2

TABLE 3. Characteristics of the solar cells measured at 210 suns, AM1.5

Type of cell	V_{oc}(V)	J_{sc} (A cm^{-2})	η (%)	FF	R_s (mΩ cm^2)
1.43 eV	1.120	4.08	21.1	0.85	≈ 5
1.69 eV	1.320	2.78	19.2	0.86	≈ 10

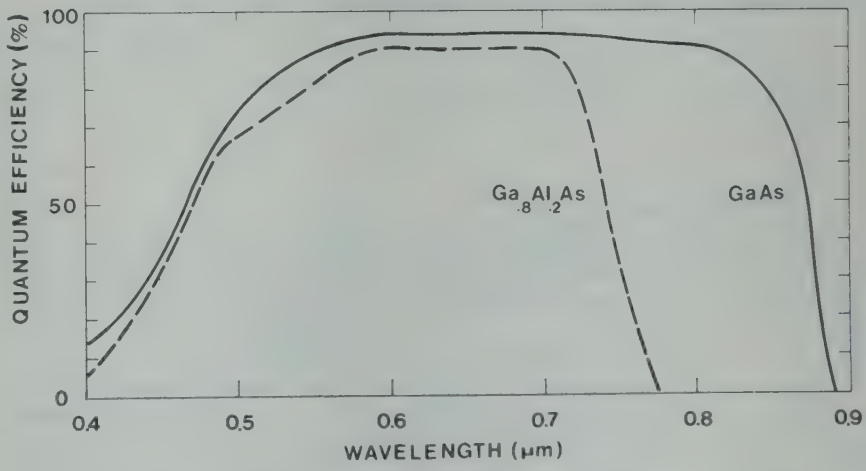

Fig. 2 Experimental quantum efficiency as a function of the wavelength for low and high band-gap solar cells.

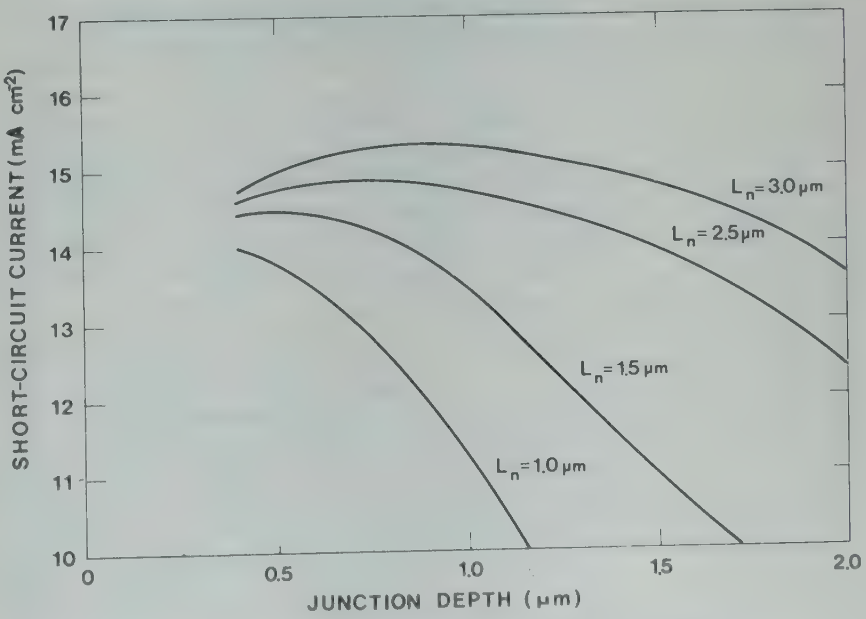

Fig. 3 Calculated short-circuit current density of the $Ga_{0.80}Al_{0.20}As$ cell as a function of junction depth for different values of the diffusion length L_n in the active layer for AM1.5 illumination.

at 1000 suns and to 0.67 at 2500 suns. Also the 1.43-eV solar cell had a maximum fill factor of 0.85 at 200 suns and a lower value of 0.83 at 1000 suns. Preliminary life tests were performed on two 1.43-eV band-gap cells, forward biased with a 2-A dark current simulating a concentration of 300 suns. The biased cells were continuously subjected to thermal cycles from +50 to +190 °C in air with 1 h permanence at the higher temperature for each cycle. Quantum efficiency, dark current-voltage curves, short-circuit current, open-circuit voltage and conversion efficiency were periodically monitored. After 1100 h no degradation effects were seen for any characteristics.

5. DISCUSSION

1.43 and 1.69 eV band-gap $Ga_{1-x}Al_xAs$-GaAs solar cells were fabricated by the LPE technique and were characterized at different concentration ratios up to 2500 suns. A simplified structure, low series resistance, high conversion efficiency and good reliability make these cells very suitable for high-concentration high-efficiency photovoltaic systems.

The 1.69-eV band-gap cell-growth technology does not seem to be much more complicated than the technology for 1.43-eV band-gap conventional cells. The same technology could probably also be extrapolated to produce higher band-gap $Ga_{1-x}Al_xAs$ cells for a three-cell efficient combination together with GaAs(1.43 eV) and silicon(1.1 eV) cells. With an aluminium content x of 0.37 in the active layer, a 1.92-eV band-gap cell can be obtained, approximating the cross-over point between the direct and indirect band gap.

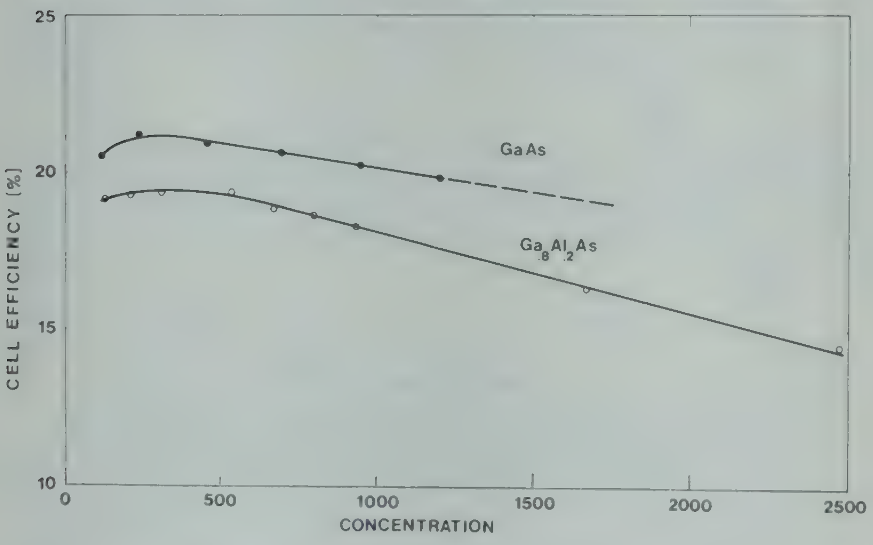

Fig. 4 Conversion efficiencies of the two cells measured as a function of the concentration ratio at AM1.5.

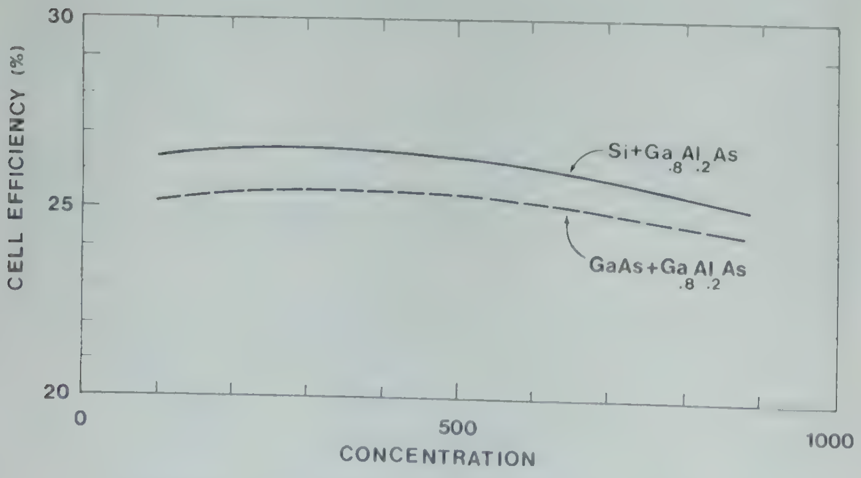

Fig. 5 Expected total conversion efficiencies for a spectrum-splitting system: filter cut-off, $\lambda_0 = 0.73$ µm; transmission loss, 10%; reflection loss, 5%.

On the basis of the experimental data reported in Figs. 2 and 4 the expected total conversion efficiency can be estimated for a combined system including an optical spectrum-splitting filter, a 1.43-eV band-gap cell and a 1.69-eV band-gap cell. Similarly, the expected total conversion efficiency of a combined system including the filter, the same 1.69-eV band-gap cell and a silicon cell specifically designed and optimized is calculated. Both results are reported in Fig. 5. The silicon cell was assumed to have the same characteristics as reported in ref. 4. In conclusion, $Ga_{1-x}Al_xAs$ LPE technology was demonstrated to be suitable for the fabrication of high-performance solar cells with band-gap energy ranging from 1.43 to 1.69 eV and could probably be extended to obtain higher band-gap cells. $Ga_{1-x}Al_xAs$ LPE is therefore a very promising technique for high-efficiency multigap photovoltaic applications.

Nevertheless, it is very likely that any real success of this approach will be conditioned by the development of large-scale production processes for the growth and fabrication of $Ga_{1-x}Al_xAs$ solar cells.

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From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

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Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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ASSET 3/6

Abstracts of Selected Solar Energy Technology

Volume 3, Number 6, June 1981

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OFFICIAL NEWSLETTER OF THE UNITED NATIONS CONFERENCE
ON NEW AND RENEWABLE SOURCES OF ENERGY

THE UNITED NATIONS UNIVERSITY

UNITED NATIONS CONFERENCE ON
NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

Unless otherwise explicitly stated, the views expressed in the abstracts and articles contained herein are not necessarily those of the United Nations University.

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Recipients are encouraged to provide **ASSET** with copies of their publications concerning the technological and socio-economic aspects of solar, bioconversion and wind energy utilization for abstracting in future issues.

THE UNITED NATIONS UNIVERSITY
Printed in Japan 1981

INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy

  B1 Radiation Measurement
  B2 Photovoltaic Conversion
  B3 Active Thermal Systems
  B4 Passive Thermal Systems

C. Bioconversion Energy

  C1 Biomass Production and Conversion
  C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

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Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

364/81 DOMESTIC ENERGY CONSUMPTION IN INDIA (PONDICHERRY REGION). C.L. Gupta and K.U. Rao (Tata Energy Research Institute (Field Unit), Pondicherry (India)) and V.A. Vasudevaraju. Energy, vol. 5, p. 1213-22 (1980).

Surveys have been conducted in 200 households in and around Pondicherry, India, in 45 households of each of two rural and two semi-urban areas, and in 20 households in an urban area. The families surveyed cover the economically weaker section, the low-income group, the middle-income group, and the high-income group; there were 60 families in each of the first three categories in rural and semi-urban areas and 20 of the fourth category in the urban area. The objective of this empirical study was to determine the daily household-energy consumption for cooking, lighting, heating water, and for household electrical appliances. The average energy content of the commercial and non-commercial fuels used for cooking, heating water and lighting was determined on a per capita daily basis. The seasonal and hourly variations were also determined for cooking and lighting loads. The baseline data, which give the caloric values and costs for various kinds of fuels, are presented in the appendix. This survey contains previously unavailable data on village-level domestic-energy needs, their magnitudes and diurnal profiles. 9 refs.

365/81 ALTERNATIVE NEW ENERGY OPTIONS FOR BRAZIL. Instituto de Energia Atomica, Centro de Engenharia Nuclear, São Paulo, Brazil (Oct. 1978) 86p.

A brief is presented on the technological state-of-development and economics of the new alternative energy sources which might in the future become viable energy options for Brazil.

366/81 POTENTIAL OF RENEWABLE ENERGIES IN PLANNING THE DEVELOPMENT OF RURAL AREAS. T.A. Lawand (McGill University, St. Anne de Bellevue, Quebec (Canada)). P. 757-71 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

The use of renewable energy sources for meeting the energy needs of the rural sector is discussed. A list of these sources, their applications and state-of-the-art are presented, and their potentials are described. Means for exploiting renewable-energy technology and systems for the development of rural sectors are also considered.

367/81 ENCYCLOPEDIA OF ENERGY-EFFICIENT BUILDING DESIGN: 391 PRACTICAL CASE STUDIES. VOLUMES I and II. K. Lee. Environmental Design and Research Centre, Boston, MA, USA (1977) 1025p.

Included in these two volumes are abstracts of 391 building projects that apply innovative methods, using either natural and renewable energy sources or concepts of energy conservation, in building design. Each project is described in a concise abstract and illustrations provided by contributors are included.

B. SOLAR ENERGY

368/81 ARCHITECTURAL DESIGN BASED ON CLIMATE. M. Milne and B. Givoni. P. 96-113 of Energy Conservation Through Building Design. McGraw-Hill, New York, NY, USA (1979).

This chapter describes the use of the psychrometric chart for energy-conservation design and establishes a process whereby the designer can systematically match design solutions to climatic conditions. The method permits an identification of least-purchased energy-design strategies by utilizing the natural effects of sun, wind, and night-time cooling. Appropriate mechanical equipment is selected only when these methods are insufficient. Rather than the architect presenting the mechanical engineer with a design and the question of how much mechanical equipment is needed, the approach implies that the architect and engineer first ask to what extent can natural-energy systems be used; can human comfort conditions be achieved with no mechanical equipment; and, if mechanical systems are required, how can they best be integrated into the building design to minimize purchased-energy use. To present this method of design, a description is presented of human-comfort zones on the psychrometric chart, and the design solutions available to meet comfort requirements under the various climate conditions are detailed. How these alternatives might be incorporated into a climate-based architectural-design method is summarized. For readers who are not fully familiar with the psychrometric chart, a technical note at the end of the chapter reviews basic psychrometrics and includes common engineering definitions of the terms referred to in the chapter.

369/81 REPORT OF A VISIT TO AGRICULTURAL RESEARCH STATIONS USING SOLAR ENERGY SYSTEMS (農業関係太陽エネルギー利用施設見学会報告). Ito T. (Ikutoku Technical University, Atsugi (Japan)). Solar Energy (Taiyō Enerugī), vol. 7, no. 1, p. 41-9 (1981). In Japanese.

A study tour was organized by the Research Station of Agriculture and Engineering of the Japanese Ministry of Agriculture and Forestry, on 7 Nov. 1980 to view the latest developments in solar energy technology at four Japanese agricultural institutions: Department of Horticulture, Chiba University; Central Electric Institute; Research Station on Agriculture and Engineering; and Department of Agricultural Engineering, University of Tsukuba. At each institution, experiments on various devices to store energy were being conducted. With special emphasis on greenhouses, some of these projects included: the use of insulating material for curtains; a dehumidifying ventilation system using sensible heat; a water-heating system using forced ventilation; heat-pump systems to control temperature and humidity; a greenhouse using underground heat-exchange systems and reflecting mirrors placed along one wall; and a heat-exchange apparatus using polyethelene films and vinyl chloride pipes. At the Research Station of Agriculture and Engineering, an experiment is being carried out to raise cattle in a controlled environment using a solar-heating and -cooling system. Other devices also being tested in order to achieve high heat-collecting efficiencies at low cost include a shallow solar pond, especially designed for agricultural use, and a concentrating collector. The work of a biomass-energy group at the University of Tsukuba, experimenting with methane fermentation, is included.

370/81 PLASTICS HONEYCOMB SOLAR COVERPLATES. N.R. Gordon and G.L. Tingey (Battelle Pacific Northwest Laboratory, Richland, WA (USA)). P. 419-22 of Proceedings of the Solar 79 Northwest Conference (held Seattle, WA, USA, 10 Aug. 1979). 1979.

Honeycomb-shaped materials bonded between two plates are effective in reducing heat transfer. This concept was applied to the design of an integral solar coverplate using a transparent plastic honeycomb with transparent plastic skins bonded to both the top and bottom of the honeycomb core. Structurally sound panels have been fabricated and tested. A plastic coverplate with glass-reinforced polyester skins and a Mylar honeycomb core is compared to a standard two-pane low-iron glass coverplate. Under ideal weather conditions (clear skies with no wind), the honeycomb coverplate is about 12% less efficient than the insulated glass, but with a 24 km/h wind or with cloudy or overcast skies, the efficiency of the plastic coverplate can surpass that of the glass. Current estimates indicate the potential of producing a honeycomb-core coverplate which would be much lighter in weight and possibly more economically attractive than the insulated glass coverplate.

371/81 MICROSTRUCTURAL AND MECHANICAL PROPERTY EVALUATION OF ZINC OXIDE COATED SOLAR COLLECTORS. C. Homhual, O.T. Inal, L.E. Murr, A.E. Torma and I. Gündiler (Department of Metallurgical and Materials Engineering, New Mexico Institute of Mining and Technology, Socorro, NM 87801 (USA)). Solar Energy Materials, vol. 4, p. 309-32 (1981).

Black zinc oxide surfaces produced in an alkaline bath on leaf zinc, electroplated zinc on mild steel and hot-dip zinc coated mild-steel substrates show high (6-9) selectivity (α_s/ε at 100 °C) values for solar-collection applications. These overgrowths are seen to maintain their physical integrity as well as optical properties ($\alpha_s > 0.95$) following exposure to 250 °C (2 h) in air, possess high strength of attachment to their substrates (> 200 kg/cm^2) and are quite ductile (170° bend previous to fracture). Structural analyses of the overgrowths show them to consist of oxide particles within which the elemental component of the oxide is seen to be distributed in the unassociated form. The plating parameters utilized in the deposition of the coatings are seen to alter the quantity and distribution of the elemental component and effect optical properties of these surfaces. 15 refs.

372/81 SELECTIVE SURFACES. H. Tabor (Hebrew University, Jerusalem (Israel)). P. 253-86 of Proceedings of the Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

The basic requirements of a practical selective surface for a solar collector and the physics of selective surfaces are discussed. Several types of selective surfaces are considered in detail, including: nickel-black, copper oxide, thin layers of semiconductor, multiple dielectric layers, selective paints, and topological coatings. Limitations imposed by coating thickness and applications of selective coatings in reducing heat loss are discussed. An equation is given for determining the efficiency of a flat-plate collector which is used to assess the performance of selective surfaces. 70 refs.

373/81 SOLAR SELECTIVE COPPER-BLACK LAYERS BY AN ANODIC OXIDATION PROCESS. H.S. Potdar, N. Pavaskar, A. Mitra and A.P.B. Sinha (National Chemical Laboratory, Poona 411 008 (India)). Solar Energy Materials, vol. 4, p. 291-9 (1981).

Optical and structural properties of copper-black layers prepared by the anodic oxidation of copper in an alkaline medium have been studied. They have high visible absorption ($\alpha \approx 0.95$) and low infrared emission ($\varepsilon \approx 0.2$) with a cut-off at 3.5 µm. X-ray diffraction, electron diffraction and ESCA studies of these layers indicate that they are a mixture of cuprous and cupric oxides. The crystallite size is between 100 to 200 Å. 15 refs.

374/81 ANTIREFLECTION COATINGS ON METALS FOR SELECTIVE SOLAR ABSORBERS. S. Yoshida. Thin Solid Films, vol. 56, p. 321-9 (1979).

The optical characteristics and heat resistance of a TiO_x-Ti structure are discussed. First, the conditions required to eliminate reflection were theoretically calculated. Then, using a reactive-vapour coating, TiO_x was produced and its optical constant was measured. It was found that an absorber of TiO_x-Ti has ∿75% efficiency when κ is 100 and T_b is 500 °K, and was stable after heating to 250 °C in a vacuum for more than 50 hours. 18 refs.

375/81 EFFICIENT AND STABLE PHOTOELECTROCHEMICAL CELLS CONSTRUCTED WITH WSe_2 AND $MoSe_2$ PHOTOANODES. G. Kline, K. Kam, D. Canfield and B.A. Parkinson (Ames Laboratory, Energy and Mineral Resources Research Institute, Iowa State University, Ames, IA 50011 (USA)). Solar Energy Materials, vol. 4, p. 301-8 (1981).

Single crystals of n-WSe_2 and n-$MoSe_2$ were grown and employed as the photoanode in a regenerative photo-electrochemical cell with an iodide-triiodide electrolyte. Solar to electrical power-conversion efficiencies of 10.2 and 9.4% were achieved on selected crystals of WSe_2 and $MoSe_2$, respectively. Products of a photocorrosion reaction from a $MoSe_2$ electrode could not be detected in the electrolyte after one month of continuous operation. The photocurrent spectra and optimization of the electrolyte are also discussed. 26 refs.

376/81 ENERGY CONVERSION THROUGH ELECTROCHEMICAL SOLAR CELL BASED ON CdS FILM PHOTOANODE. T.K. Bandyopadhyay, M.N. Majumdar and S.R. Chaudhuri (Department of Chemistry, University Kalyani, Kalyani 741235 (India)). Journal of Indian Chemical Society, vol. 56, p. 1125-8 (1979).

Data on photo-electrochemical solar cells of the CdS film-polysulphur electrolyte-Pt type obtained by the deposit of an n-type CdS film on (a) a Cd sheet and (b) a Ti support are presented. The characteristics of this cell when exposed to polychromatic light were examined. 10 refs.

B2. PHOTOVOLTAIC CONVERSION

377/81 DIRECT ENERGY CONVERSION: AN ATTRACTIVE OPTION FOR DEVELOPING COUNTRIES. V.C. Sharma (Department of Physics, University of Benin (Nigeria)). Energy, vol. 5, p. 1257-9 (1980).

Solar energy will play a key role in direct energy conversion. The conversion efficiencies of a variety of silicon and GaAs solar cells are described. A cost comparison of silicon and GaAs hybrid solar-cell systems shows current average costs of US$0.044 and US$0.0675 per kWh in the USA and US$0.11 per kWh in Nigeria. A brief account of current developments and future prospects is given for integrated tandem solar cells and for electrochemical solar cells. 19 refs.

378/81 STUDY ON JUNCTION PROPERTIES OF n-CdS/p-InP HETERODIODES BY USING INJECTION ELECTROLUMINESCENCE. Yoshikawa A., Ishizaki O., Kasai H. and Nishimaki M. (Chiba University, Chiba (Japan)). Transactions of the Institute of Electronics and Communication Engineering of Japan, Section E, no. 4, p. 224-8 (Apr. 1979).

Results obtained from a study on junction properties of n-CdS/p-InP heterodiodes which were prepared as solar cells by the close-spaced technique are described. The junction properties were examined by means of injection electroluminescence. It has been shown that these diodes have a very low interface state density, at least in deep levels, even for an as-grown sample from the fact that only electroluminescence due to the band-to-band transitions is observed at room temperature. At liquid-nitrogen temperature, however, the luminescence spectra originating from both band-to-band and free-to-bound transitions were observed. The energy difference between the two spectral peaks was found to be 67 meV, which corresponds to the activation energy of typical acceptors in InP. The internal electro-luminescent quantum efficiency was 12.8% at 77 °K.

379/81 HIGH EFFICIENCY GaAs-GaAlAs SOLAR CELLS FOR VERY HIGH CONCENTRATION SYSTEMS. E. Fanetti, C. Flores and G. Guarini (Centro Sperimentale Metallurgico, Milan (Italy)). From the Eighteenth International Conference on Solar Energy (held Milan, Italy, 23 Sept. 1979). Centro Sperimentale Metallurgico, Milan, Italy (Oct. 1979) 17p.

Basic data on design and processing of GaAs-GaAlAs solar cells for high concentration ratios are briefly reported. Conversion efficiencies up to 23% at 100 suns and 17% at 925 suns have been measured. The temperature variation of the conversion efficiency was also checked up to 200 °C and a close correlation between theoretical and experimental results was generally found.

380/81 STUDY OF ION IMPLANTED n^+ LAYERS FOR SILICON SOLAR CELLS. F. Zignani (University of Bologna, Bologna (Italy)), F. Cembali, R. Galloni, L. Pedulli and M. Servidori. P. 113-24 of Proceedings of the Photovoltaic Solar Energy Conference (held Luxembourg, Luxembourg, 27 Sept. 1977). D. Reidel Publishing Co., Boston, USA (1978).

The methods of obtaining silicon solar cells of large size and at low cost were studied. Phosphorous ions were implanted in monocrystalline silicon of two orientations. The relationship between the direction of substrates and the energy required for implantation, the relationship between the damage distribution through implantation and the thickness of the SiO_2 film, the temperature required for heat treatment and the electrical activation rate were reviewed. The distribution of ions which were implanted and the direction of damage depth were obtained from proton back-scattering analysis. Transmission-electron-microscopy analysis was used to determine the kind of damage introduced. The ion-concentration depth after implantation was 0.3-0.4 μm from the surface, and the damage depth ∿0.2 μm, which was repaired by heat treatment at a high temperature (∿5-600 °C). A trial-model silicon solar cell with an anti-reflection coating had an efficiency of ∿13% which could be optimized by heating after implantation. 13 refs.

381/81 EFFICIENT INDIUM TIN OXIDE/POLYCRYSTALLINE SILICON SEMICONDUCTOR-INSULATOR-SEMICONDUCTOR SOLAR CELLS. A.P. Genis, P.A. Smith, K. Emery, R. Singh and J.B. DuBow (Department of Electrical Engineering, Colorado State University, Fort Collins, CO 80523 (USA)). Applied Physics Letters, vol. 37, p. 77-9 (1980).

Using neutralized-ion-beam sputtering, high-efficiency (10.94%, AM1) and large-area (total area, 11.46 cm^2) indium tin oxide/polycrystalline silicon semiconductor-insulator-semiconductor solar cells were fabricated. The important steps in the fabrication were the proper surface preparation and the incorporation of hydrogen during milling and oxidation of the substrate. The photovoltaic-conversion parameters were V_{OC} = 0.526 V, J_{SC} = 27.39 mA/cm^2, and FF = 0.759. 8 refs.

382/81 NOVEL SOLAR CELL CONCENTRATOR PHOTOVOLTAIC CONVERTER SYSTEM. FINAL REPORT, APRIL 1979. L.W. James, H.A. Vander Plas and R.L. Moon (Sandia Laboratories, Albuquerque, NM (USA)). SAND-79-7048 (Dec. 1979) 91p. NTIS. US$10.50.

Attainment of photovoltaic-conversion efficiencies greater than 25 to 30%, thought necessary to make concentrator photovoltaics economical, seems possible if the solar spectrum is more efficiently used by splitting the spectrum and using solar cells of different bandgaps. For initial work on multi-bandgap concentrator solar cells, the spectrum was split by an optical filter which transmits light above 1.5 eV and below 1.1 eV and reflects light between 1.1 and 1.6 eV. Theoretical modelling of possible conversion efficiencies led to the choice of the filter bandpass energies and practical solar-cell fabrication considerations have led to the choice of silicon and the $Al_x/Ga_{1-x}/As$ system for initial development work. Special silicon concentrator solar cells with a $p^+:n^-:n^+$ structure have been designed for this application and have attained apparent cell conversion efficiencies of 16.2% at a current ratio of 455 suns. An $Al_{0.93}Ga_{0.07}As/Al_{0.17}Ga_{0.83}As$ solar cell with a bandgap near 1.6 eV has attained a cell conversion efficiency of 20.4% at a flux concentration of 525 suns. These cells have been packaged and combined with the spectrum-splitting filter to give conversion efficiencies at 50 °C, including the filter and the cells, of 27.0% at 113 suns and 26.0% at 489 suns.

383/81 PERFORMANCE OF SILICON SOLAR CELLS IN FRONT OF A WATER ABSORBER. J.D. Arora and P.C. Mathur (University of Delhi, Delhi (India)). International Journal of Electronics, vol. 47, no. 2, p. 167-70 (1979).

I-V curves as a function of path length in ordinary and distilled water were measured for two n on p diffused-junction silicon solar cells. The normalized short-circuit current and normalized conversion efficiency for the cells for different path lengths were determined from the I-V curves and comparison of the experimental results was made with theoretical calculations. It was found that the agreement between the theoretical and experimental results was better for the cell with a low substrate acceptor concentration. The agreement was still better with distilled-water results. 5 refs.

384/81 SOLAR POWER FOR ELECTRODIALYSIS. W.P. Harkare, R.A. Mahabala, K.P. Govindan and S.D. Gomkale (Central Salt and Marine Chemicals Research Institute, Bhavnagar (India)). P. 382-91 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

This institute has developed ion-exchange membranes and an electrodialysis technique for desalination of brackish water. Application of this technique to produce drinking water from brackish-water sources, sufficient for an average family in rural areas, where electrical power is not available, was investigated. Photovoltaic cells were used to power the system.

B3. Active Thermal Systems

385/81 THIN-FILM SOLAR COLLECTOR. T. Engel (Verfahrenstechnik, 6056 Heusenstamm, Fed. Rep. of Germany). Sunworld, no. 2, p. 24 (Nov. 1976).

This collector was specifically designed for high-efficiency operation in regions where insolation is intermittent due to broken cloud cover. It consists of two metal (or plastic) layers which are welded together at the edges. The top layer is dimpled so that, regardless of the position of the sun, some light hits the surface perpendicularly. The space between the layers is filled with a thin film (3 to 5 mm) of water. The top layer is coated with an epoxy-base resin which absorbs 94% of the incident radiation, is a good heat reflector, and is a polymer into which carbon particles are rolled. This modular system responds very rapidly to changes in incident radiation and has an efficiency of 80%.

386/81 SOLAR WATER HEATERS AND RURAL DEVELOPMENT. V.K. Gupta (Indian Institute of Technology, Kanpur (India)). P. 716-21 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

This paper presents complete design details of two different domestic solar water heaters based on the natural-convection heat-exchange principle. The heaters are of storage-cum-collector type and thermosyphon type. The design proposed may also be used for meeting the small hot-water demands in small-scale industries. The heaters have been tested at Kanpur, India, to study their thermal performance behaviour in day and night under normal and adverse weather conditions. The experimental data and test results are analysed.

387/81 SOLAR WATER HEATER DESIGNED MAINLY AIMING AT THE ECONOMICAL EFFICIENCY OF INSTALLATION COST (設備コストの経済的能率を主眼として考案した太陽熱温水器). Kobayashi G. (Atami Taiyōnetsu Kenkyūsho, Atami (Japan)). P. 33-6 of Proceedings (Kōen Ronbunshū) of the Third Research Presentation Meeting (Dai-sankai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nihon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 5-6 Dec. 1977). Japan Solar Energy Society, Bunkyo-ku, Tokyo, Japan (1977). In Japanese.

This device is a flow-down type solar water heater in which improvements were made on the water flow pipes, the light concentrator, the heat-storage device (especially the device for protection against wind), and the hot-water storage tank. This solar water heater aims at a pay-back period of less than 1.5 years for the complete installation. A pay-back period of less than 1.5 years is possibly attainable if the temperature of the hot-water supply is set at approximately 50 °C.

388/81 SOLAR WATER PUMPING. M.N. Bahadori (University of Shiraz, Shiraz (Iran)). P. 1191-221 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

The principles of solar water pumping are briefly described. The mechanical energy needed for pumping water may be produced by thermodynamic- or direct-conversion methods. In thermodynamic conversion, a fluid with high internal energy is produced in solar collectors or concentrators. The internal energy of the fluid may be utilized in Rankine, Brayton, or Stirling cycles or in specially designed devices. The direct conversion includes photovoltaic, thermoelectric and thermionic processes. With the current prices of solar cells, photovoltaic water pumping seems to be economically competitive with the current solar Rankine-cycle system in the power ranges of below 5 kW, especially when both systems have to be imported by a developing country. 34 refs.

389/81 SURVEY OF EXISTING SOLAR POWERED REFRIGERATION SYSTEMS FOR STORAGE OF FOOD STUFFS AND A METHOD OF CALCULATION FOR A SOLAR POWERED PLATEN-MUNTERS SYSTEM. P. Svensson and H. Hansson (Tekniska Högskolan, Institute för Värmeoch Kraftteknik, Lund (Sweden)). Institute för Värmeoch Kraftteknik, Lund, Sweden (Aug. 1979) 104p.

This paper presents a thorough literature study of solar-powered refrigeration for preservation of food stuffs. The operation of some systems used in connexion with solar energy is also described. A calculation of a Platen-Munters' unit is made so that it can be used as a basis for designing similar units. The described unit has a refrigeration chamber of 4 m^3 and is heated by flat-plate solar collectors. It is independent of electricity and cooling water.

390/81 LIQUID DESICCANT SOLAR AIR CONDITIONER AND ENERGY STORAGE SYSTEM. H.I. Robison (Coastal Carolina Energy Laboratory, University of South Carolina, Conway, SC (USA)). Vol. 2, p. 1620-2 of Proceedings of the Thirteenth Intersociety Energy Conversion Engineering Conference (held San Diego, CA, USA, 20 Aug. 1978). CONF-780801-P2.

A liquid desiccant air-conditioning system has been designed and is being constructed for testing. The absorbate is water and the absorbent is triethylene glycol. Shallow well water removes the sensible heat. Direct solar radiation reactivates the dilute absorbent solution as it flows down corrugated trickle collectors. Insolation is used for mass transfer, and very little energy is lost to the ambient-air stream as sensible heat. Parasitic losses are small as no blower is necessary in the regenerator and heat exchangers recover sensible heat absorbed by the glycol. A small, concentrated solution, flywheel storage system makes continuous operation possible.

391/81 VAPOR TURBINE UNITS WITH ORGANIC WORKING FLUIDS AND PROSPECTS FOR THEIR USE IN SOLAR POWER GENERATION: SURVEY. V.A. Grilikhes, M.M. Grishutin and V.S. Evseev. Applied Solar Energy, vol. 14, no. 4, p. 1-12 (1978) [English translation, of Гелиотехника, vol. 14, no. 4 (1978)].

Thanks to several favourable thermophysical and operational-technological properties of the organic materials, their use as working fluids makes it possible to significantly improve the technical and economic characteristics of vapour-turbine converters with upper-cycle temperatures of 80 to 400 °C. Examples of existing Soviet and foreign developments are used to show that the use of organic working fluids with low-level heat sources (solar energy, geothermal waters, waste heat of various industrial processes) markedly reduces the specific capital expenditures involved in developing such units.

B4. PASSIVE THERMAL SYSTEMS

392/81 SURVEY OF PASSIVE SOLAR BUILDINGS. AIA Research Corp., Washington, DC (USA)). HUD-PDR-287(2) (Feb. 1979) 178p. NTIS. US$14.50.

Classification and general descriptions of a variety of existing applications of passive solar energy designs are presented. The passive systems are defined as direct gain, indirect gain, or isolated gain. Direct-gain systems simply transfer solar insolation to the living space and to thermal mass. Designs utilizing this concept are described. Indirect-gain systems in which thermal energy is moved to a storage mass and then to the living space include mass Trombe walls, water Trombe walls, and roof ponds. Isolated-gain systems are illustrated by the thermosyphon-type building and the sun-space-type building; isolated-gain designs move heat from a collector space to a storage mass, and then to the living space. Diagrams and descriptions of the buildings cited are included along with a reference bibliography.

393/81 PASSIVE SOLAR ENERGY DESIGN AND MATERIALS. Noyes Data Corporation (Park Ridge, NJ (USA)). Noyes Data Corporation, Park Ridge, NJ, USA (1979) 399p. US$39.00.

Basic concepts and state-of-the-art of passive solar-heating and -cooling systems are discussed. Passive solar components are discussed including various window treatments, thermal-storage systems and miscellaneous components including freon-activated controls (Skylid), hinged Skylid shutters and Nightwall clips, Beadwalls, thermic diode solar panels, heat pipes, weather-responsive building skins, Skytherm roof pond, energy roof, hinged sky lites, solar room, and the Peakshaver solar collector. Over 100 buildings using specially designed components for the three major passive systems (direct gain, indirect gain, and isolated gain) are described. There are many hybrid arrangements utilizing simple mechanical aids to operate an otherwise immobile system. There are more than 200 illustrations. Cost figures provided are those given in the report cited.

394/81 DEVELOPMENT OF A SOLAR DESICCANT DEHUMIDIFIER II. V. Mei, H. Ghezelayagh, D. Gidaspow and Z. Lavan (Illinois Institute of Technology, Chicago, IL 60616 (USA)). P. 264-8 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, WA, USA (1979).

An air-conditioning system using solar energy and silica gel is described. The characteristics of this dehumidifier (transverse-flow type) are presented. 3 refs.

395/81 PROBLEMS IN CONSTRUCTION AND MAINTENANCE OF LARGE SOLAR STILL PLANTS. G.H. Goghari, G.L. Natu and S.D. Gomkale (Central Salt and Marine Chemicals Research Institute, Bhavnagar (India)). P. 231-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Solar stills, in the present context of the energy crisis and rural development, appear to be well suited for supplying good quality drinking water by desalting available saline water using the sun's energy. These systems are especially suitable for isolated villages facing acute water shortages. Solar-distillation plants of large capacities for community use were installed by the Central Salt and Marine Chemicals Research Institute. Various designs and construction materials tried so far are discussed. Long-time operation experiences are also discussed in relation to maintenance problems and the construction itself.

396/81 BASIC STUDY ON INCLINED WICK-TYPE SOLAR STILLS (傾斜ウィック型太陽熱蒸溜器に関する基礎研究). Watanabe K., Mimaki M. and Tanaka K. (Department of Engineering, Keiō University, Tokyo (Japan)). P. 9-12 of Proceedings (Kōen Ronbunshū) of the Fifth Research Presentation Meeting (Daigokai

Kenkyū Happyōkai) of the Japan Solar Energy Society (Nihon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 26-27 Nov. 1979). Japan Solar Energy Society, Bunkyō-ku, Tokyo, Japan (1979). In Japanese.

In order to improve the efficiency of solar stills, an inclined wick-type solar still was devised and various experiments were carried out by changing the inclination angle of the still and the type of wick. It was found that in comparison with a single-roofed solar still, the distillation efficiency of the inclined wick-type was quite high. Further study may be useful, especially to determine the relationship between the distillation efficiency and the optimal flow for water supplied to the still. The calculation of the heat balance inside the inclined wick-type solar still indicates that the heat-transmission rate was remarkably stable regardless of the hour of the day.

397/81 APPARATUS FOR SOLAR DISTILLATION. R.H. Bellande and D.C. Wilson (to Avant, Ltd.) US Patent 4,159,228 (26 June 1979). Filed date: 11 Oct. 1977. 4p.

An apparatus is disclosed for the solar distillation of contaminated water which includes a substantially airtight enclosure having an evaporation chamber and condensation chamber. The evaporation chamber has a lower reservoir and an upper inclined surface which is transparent to solar radiation. The condensation chamber includes a thermally conductive condensation wall and a collecting reservoir for collecting the condensed water. A thermal insulative partition is located between the evaporation chamber and the condensation chamber, and includes an upper port and a lower port. At least one thermally conductive conduit may be located within the condensation chamber and externally vented at the upper and lower portions thereof.

398/81 GREENHOUSES IN HOT CLIMATE. A.A.M. Sayigh (University of Riyadh, Riyadh (Saudi Arabia)). P. 1145-68 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

The use of shelters, natural or artificial, and special greenhouses are discussed in relation to a variety of climatic conditions. The use of passive cooling coupled with the Ruthner principle is studied, particularly with regard to its future role in continuous agricultural production. Some examples of existing greenhouses in the neighbourhood of Riyadh are discussed. Several unusual designs of greenhouses, such as those developed by Brace Research Institute and Polysolar Company, are fully discussed. Several recommendations are mentioned and all systems are compared with each other.

C. BIOCONVERSION ENERGY

399/81 TRENDS IN MICROBIAL TECHNOLOGY FOR DEVELOPING COUNTRIES. E.J. DaSilva (Division of Scientific Research and Higher Education, UNESCO, Paris (France)). P. 329-68 of Scientific and Technological Trends. Academic Press, New York, NY, USA (1980).

This work indicates the ways in which microbial technology can help provide solutions to the problems of developing countries with special concern for the problems of hunger, pollution control, health and the management of natural resources. In most societies, fermentation process have long been utilized and contributed to the growth and development of society and national economics. The utilization of many important microbial strains is at the basis of impressive technological progress. The production of traditional fermented foods, the recycling of organic residues, the production of antibiotics and amino acids, and the recent commercial interest in enzyme and genetic engineering have influenced and will continue to improve the quality of life. Microbes constitute a relatively modest investment with a high rate of return. In terms of future economic development, the microbial treasury needs to be tapped in: the conversion of arid zones into food factories; the recycling of biodegradable residues into food, feed and fertilizer; the improvement of water economies; the development of algae as an energy source; and the harvesting of energy through biochemical fuel solar cells. The report includes a list of bio-energy research and development activities and their government sponsors in 23 nations, a list of the bio-energy research, development and training programmes supported by 10 UN agencies, estimates of biomass energy production cost in eight countries, and a list of 8 under-exploited plants with potential economic value for energy, food and chemical production. 25 refs.

400/81 ASSESSMENT OF PERUVIAN BIOFUEL RESOURCES AND ALTERNATIVES. J.P. Harper, W. Smith and E. Mariani (Argonne National Laboratory, Argonne, IL (USA)). ANL/EES-TM-86 (Aug. 1979) 57p. NTIS. US$9.50.

Comprehensive assessment of the biofuel potential of Peru is based on: determination of current biofuel-utilization practices, evaluation of Peruvian biomass productivity, identification of Peruvian agricultural and forestry resources, assessment of resource development and management concerns, identification of market considerations, description of biofuel technological options and identification of regional biofuel technology applications. Discussion of current biofuel-utilization centres on a qualitative description of the main conversion approaches currently being practiced in Peru. Biomass-productivity evaluations consider the terrain and soil, and climatic conditions found in Peru. The potential energy from Peruvian agricultural and forestry resources is described quantitatively. Potential regional production of agricultural residues and forest resources that could supply energy are identified. Assessment of resource development and management concerns focuses on harvesting, reforestation, training, and environmental consequences of utilization of forest resources. Market factors assessed include: importation, internal-market development, external-market development, energy policy and pricing, and transportation. Nine biofuel technology options for Peru are identified: (1) small-to-medium-scale gasification, (2) a wood-waste inventory, (3) stationary and mobile charcoal-production systems, (4) wood distillation, (5) forest resource development and management, (6) electrical cogeneration, (7) anaerobic-digestion technology, (8) development of ethanol-production capabilities, and (9) agricultural strategies for fuel production. Applications of these biofuel options are identified for each of the three major regions - nine applications for the Costa Region, eight for the Sierra Region, and ten for the Selva Region.

C1. BIOMASS PRODUCTION AND CONVERSION

401/81 COCONUT HUSK-FUELED PILOT PLANT PUT TO TEST. NSDB Technology Journal, vol. 4, no. 4, p. 3 and 90 (Oct.-Dec. 1979).

A pilot electric-power plant, running on coconut husks, was successfully demonstrated in Laguna, Philippines. This 30-kW biomass-fed plant provides electricity for 50 remote households and a wood-carving shop using a motor. The system involves: burning coconut husks to obtain "producer gas"; filtering this gas; and driving a generator with the power of the combusted gas. The village is saving 65 to 75% of their diesel fuel consumption with this system.

402/81 IMPROVED COOKING STOVE. E.S. Virina. NSDB Technology Journal, vol. 4, no. 4, p. 60 (Oct.-Dec. 1979).

This paper refers to the construction of an open-topped cooking stove. It incorporates a fuel grate (under which is an ash receptor) traversing the central portion of the stove body. Close to this body is an air tank. An air pipe is connected to this tank and extends into the stove body downwardly with the fuel grate. This air tank makes it possible to introduce air into the stove for efficient combustion of the fuel.

C2. BIOGAS PRODUCTION AND UTILIZATION

403/81 BIOGAS TECHNOLOGY IN THE THIRD WORLD: A MULTI-DISCIPLINARY REVIEW. A. Barnett (Science Policy Research Unit, University of Sussex, Brighton (UK)), L. Pyle and S.K. Subramanian. IDRC-103e. International Development Research Centre, Ottawa, Canada (1978) 132p.

In response to the interest in biogas and other rural-energy systems shown by a number of Asian researchers, the International Development Research Centre commissioned this state-of-the-art review so that it might form a basis of further discussions concerning the direction of future biogas research. This book, is a multidisciplinary approach to the problem and attempts to review existing work rather than to champion particular solutions. The first chapter establishes in broad terms the energy options facing rural communities in the Third World and considers in detail just what is known about the technical aspects of biogas production. This is done by assembling details of known small-scale digester designs and by reviewing the literature to establish the technical parameters determining digester performance. A microapproach to the social and economic appraisal of rural technologies, which stresses both the need to examine technologies in their social context and the need to compare biogas investments with alternative uses of the resources available in specific rural locations, is presented in the second chapter. This approach is discussed in relation to a number of the better attempts that have been made to evaluate biogas. The third chapter complements the other two by presenting practical field experience. It is based on an extensive survey of a large number of biogas plants and their supporting infrastructure in India, Thailand, Indonesia, the Philippines, South Korea, and Japan.

404/81 ENERGY AND ECONOMIC ASSESSMENT OF ANAEROBIC DIGESTERS AND BIOFUELS FOR RURAL WASTE MANAGEMENT. FINAL REPORT. T.P. Abeles, D. Freedman, L.A. DeBaere and D.A. Ellsworth (University of Wisconsin, Rice Lake, WI (USA)). PB-296523 (Dec. 1978) 176p. NTIS. US$14.50.

A technological and socio-economic assessment of anerobic digester feasibility for small to mid-size livestock operations was undertaken. Three full-scale digesters and one pilot-scale facility were under various degrees of monitoring and evaluation to assess design and operational problems as they affect the adoption and establishment of farm-scale anaerobic digestors. Materials handling presented the greatest obstacle to satisfactory operation of the full-scale systems. Conversion of the biogas to electricity via standard engine-generator sets is capital and maintenance intensive. Electrical conversion requires engine-generator sets which can add 30% to the cost of the system, and which have conversion efficiencies of only 10-25%. The system becomes more economical if the biogas can be used on site for direct thermal loads, suggesting that the economic feasibility of anaerobic digesters is site specific and should be closely integrated with the total farming operation. If excess engine heat can be recovered from electrical conversion equipment, and if provisions can be made on the farm to level electrical loads and conserve energy, then the economics are enhanced. Analysis was performed for farms with 100 animal units.

405/81 BASIC STUDY OF METHANE FERMENTATION (メタン発酵に関する基礎的研究). Ushiyama I. and Kondō T. (Ashikaga Technical University, Ashikaga (Japan)). P. 13-16 of Proceedings (Kōen Ronbunshū) of the Fifth Research Presentation Meeting (Daigokai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nihon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 26-27 Nov. 1979). Japan Solar Energy Society, Bunkyō-ku, Tokyo, Japan (1979). In Japanese.

In view of the approaching energy crisis and increasing environmental problems, methane-gas production through methane fermentation is now considered an effective process to recover energy. Some basic experiments were carried out to review fermentation temperature, dilution rate and the use of seed. Chicken feces were used as the material to be fermented. After being diluted by water, it was kept in a digester installed in a thermostatic water bath. Gas-production volume was checked everyday and the pH rate every other day. The gas components were analysed every 4-5 days according to gas-production volume. After each measurement, diluted water in a digester was stirred and uniformed. Various comparative tests were made both with and without seed (fully fermented sludge which was included in the diluted water) using two different temperatures (35-37 °C for mesophilic fermentation and 53-55 °C for thermophilic fermentation). It was found that with a higher temperature the fermentation process could be shortened and that methane gas could be produced faster when seed was used, thereby shortening the whole process and stabilizing pH rate. It was suggested, however, that in the future mesophilic fermentation would be more advantageous in terms of energy recovery, and in this connexion the optimal quantity of seed may need to be analysed.

D. WIND ENERGY

406/81 WIND POWER. E.D. Howe (International Solar Energy Society, Parkville, Victoria 3052 (Australia)). Sunworld, no. 2, p. 6-9 (Nov. 1976).

This rather short and non-technical article makes a plea for improving the efficiency of wind-power generation. Hydro-electric generating systems are optimized by site selection and modification, and the author suggests that more careful attention should likewise be given to site selection for wind-power systems. Site modification should also be considered in order to maximize air currents and wind reliability. The article presents a brief outline of some interesting wind-power systems at various locations around the world.

407/81 CURRENT DEVELOPMENTS IN SMALL WIND ENERGY CONVERSION SYSTEMS. A.C. Hansen and C.P. Butterfield (Rockwell International, Golden, CO (USA)). Journal of Industrial Aerodynamics, vol. 5, p. 337-56 (1980).

The characteristics of wind generators under development in the USA with capacities between 2 - 40 kW are presented. The cost of energy supply by these wind generators of various capacities are determined assuming mass production. 23 refs.

408/81 CRETAN WINDMILLS. M.T. Kanaki and S.D. Probert (School of Mechanical Engineering, Cranfield Institute of Technology, Bedford MK43 0AL (UK). Applied Energy, vol. 5, p. 215-22 (1979).

The Cretan windmill comprises a shaft directed slightly above the horizontal, with radial spars, each connected to its neighbours at its tip, and also wired at its tip to an extension of the shaft in the form of a bowsprit. Triangular sails are set from each spar, with one edge aligned with the spar and another with the circumference of the rotor, the free end of the sail being tied to the neighbouring spar. Such a design has high sensitivity to low wind speeds, and the sails are self-feathering in high winds. 22 refs.

E. ENERGY STORAGE

409/81 CHARGE TIME OF A GRAVEL-FILLED HEAT STORING SYSTEM. R.R. Avezov and S.K. Niyazov (Physical-Technial Institute, Tashkent, Uzbek SSR (USSR)). Applied Solar Energy, vol. 13, no. 3, p. 58-9 (1977) [English translation of Гелиотехника, vol. 13, no. 3, p. 76-7 (1977)].

A theoretical and experimental investigation of the charge time of a gravel-filled heat-storing unit is reported for different velocities of filtration of the coolant and different wall geometries.

410/81 INVESTIGATION OF HEAT STORAGES WITH SALT HYDRATE AS STORAGE MEDIUM BASED ON THE EXTRA WATER PRINCIPLE. Thermal Insulation Laboratory, Danmarks Tekniske Hoejskole, Lyngby (Denmark). EUR-6646 (Part 2) (1980) 83p. NTIS.

UNCNRSE

CONFERENCE NEWS 8

PREPARATORY COMMITTEE FOCUSES ON REQUIREMENTS FOR PROGRAMME OF ACTION

I. OPENING

The Preparatory Committee of the UNCNRSE met in its third session in New York from 30 March to 17 April to begin the process of formulating a programme of action for the UNCNRSE.

The items of the agenda adopted for this session were:

- Adoption of the agenda
- Substantive preparations for the Conference
- Preparations at the regional level
- Preparations at the national level
- Preliminary draft outline of a programme of action
- Provisional agenda for the UNCNRSE
- Draft rules of procedure for the Conference
- Provisional agenda for the fourth session of the Preparatory Committee
- Adoption of the report of the Preparatory Committee

The opening statement of Mr. Enrique V. Iglesias, the Secretary-General of the Conference, reported on the state of preparations for the UNCNRSE (highlights of that statement were reported in UNCNRSE Conference News 7).

The Chairman of the Preparatory Committee, Mr. Makoto Taniguchi, in his opening statement noted the marked improvement in the state of Conference preparations since the second session of the Committee. He found that the close links that had been maintained by the committee's officers and the Conference Secretariat in the intervening period had been extremely useful to all concerned. With the help of several Governments, the capacity of the Conference Secretariat had been enhanced and excellent work carried out, particularly in regard to the intensive series of meetings of the technical panels and ad hoc groups of experts which culminated in the deliberations and report of the Synthesis Group. In his opinion, the necessary analytical material was now available to enable the Preparatory Committee to consider the preliminary draft outline of the programme of action. He warned that the complexities inherent in evaluating alternative sources of energy and of devising a programme applicable to regions with widely differing geographical conditions and disparate stages of economic and social development would require patience, foresight and understanding. He was convinced that the Preparatory Committee must devise a realistic and feasible programme of action that might appropriately include short-, medium- and long-term approaches focusing on the subregional and regional as well as the international levels. He noted that an understanding of such issues as the flow of information, transfer of technology, education and training, research and development, technical co-operation and funding, which are related to the North-South dialogue, would be vital to the success of the Conference, and that close co-operation between developing and industrialized countries would therefore be essential. He observed that the Conference would test whether the United Nations could be a useful organization to handle such an important issue as energy and would provide a good opportunity for co-ordinating and unifying the energy activities of the various organs and agencies of the UN system. The Chairman concluded that the Conference could not be a panacea and would not in itself solve the problems, but that the Conference was the beginning of a long journey of transition from the current energy system to a more mixed system in which NRSE will be used more extensively. Thus, the programme of action should not be a mere description of the actual or potential situation, but should contain concrete elements to be implemented after the Conference.

II. PREPARATIONS FOR THE CONFERENCE

In considering the substantive preparations for the Conference, the Preparatory Committee examined a preliminary version of the progress report of the Secretary-General of the United Nations. This report presents the progress made in preparing for the Conference, covering: the augmentation of technical expertise of the Conference Secretariat; the regional activities carried out in preparation for the Conference; the provision of technical assistance to interested developing countries in their preparations for the Conference; national papers that have been submitted to the Conference Secretariat; the exhibitions-cum-demonstrations at the Conference site; the public-information activities that have been undertaken to publicize and promote awareness of the Conference and the issues before it both prior to and during the Conference itself; and the support of the intergovernmental and non-governmental organizations.

This was followed by a general debate on: the substantive preparations for the Conference, including the Progress Report of the Secretary-General just mentioned, the reports of the technical panels and ad hoc groups of experts, the report of the synthesis group, and the activities of the relevant organs, organizations and bodies of the UN system in the field of NRSE; the preparations at the regional level; and the preparations of the national level. Representatives of 47 Governments and 14 UN organizations participated in the discussion. The delegations expressed their general satisfaction with the progress that had been made in preparations for the Conference since the second session of the Preparatory Committee. The work undertaken by the technical panels, ad hoc groups of experts and the synthesis group had been viewed as being of generally high quality, although some delegations had expressed

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reservations or disagreements on points of detail. In the view of many delegations, the report of the synthesis group contained much material that would be useful in developing the draft programme of action. The summaries of preparations for the UNCNRSE at the national level contained in the statements of many of the national delegations did much to enrich general understanding of the needs and objectives of the Conference. It was evident from the debate that activities at the sub-regional and regional levels, especially by the regional commissions, were already substantial and were useful to Governments. Similarly, there was evidence of growing co-operation and co-ordination among UN bodies and agencies in regard to NRSE. In the course of the debate, many delegations indicated in general terms their expectations for the draft programme of action. These views proved to be of considerable assistance in considering the preliminary draft outline of a programme of action.

III. PRELIMINARY DRAFT OUTLINE OF PROGRAMME OF ACTION

In introducing the preliminary draft outline of a programme of action for the Conference, the Secretary-General of the Conference emphasized that the draft was a conceptual sketch aimed at initiating comments, criticisms and suggestions so that the text would reflect the views and interests of the entire international community. During his remarks introducing the preliminary draft outline, the Secretary-General of the Conference noted that there were several major factors constituting the challenge of developing NRSE: to provide the different countries of the developing world with equally rising amounts of energy to ensure its development; to plan for the transition from the use of primarily hydrocarbon fuels to a more realistic and pluralistic energy supply; to promote alternative and more efficient solutions to the crisis in traditional-energy systems; and to unite the international community of interests in promoting NRSE and thereby accelerate development. In his opinion the programme of action should be relatively brief and concise, carrying a clear political message concerning the role that NRSE can play in the future.

The preliminary draft outline begins with a challenge to enhance the contribution of NRSE in order to provide, rapidly and equitably, a sustainable supply of energy, particularly in the context of meeting the growing energy requirements in developing countries in order to accelerate their economic and social development.

The first principal objective of the programme of action is to increase and maintain awareness and understanding at national, regional and international levels of the role of NRSE in the energy transition, with due consideration to the state of advancement of different technologies and to social and cultural factors. Proposed actions to achieve this are: the collection of information on the contribution of NRSE to energy supplies, on the progress achieved in the development of NRSE, and on the conservation and efficient use of NRSE; and the promotion of social acceptability at national, rural and community levels.

The second objective is to strengthen national capabilities for the effective incorporation of NRSE into the national energy policy and planning process through the strengthening of relevant institutional infrastructures. On a national level this would entail the establishment or strengthening of government offices designed to deal with over-all energy assessment, planning and policy formulation, closely linked with global development planning; the integration of NRSE into the work of energy planning offices or the establishment of co-ordinating mechanisms between offices dealing with energy planning and those handling NRSE; and the establishment or strengthening of institutional mechanisms designed to secure an adequate role for NRSE in integrated rural development programmes. Other actions include: the establishment of institutional mechanisms designed to deal with project identification and implementation; making provisions within such organizations for adequate operation and maintenance requirements; the establishment of adequate institutional mechanisms for the assessment of manpower needs and training requirements, and for the formulation and implementation of training programmes; and the establishment of institutions dealing with research and development. Also required is the establishment and strengthening of institutions dealing with information and data collection and dissemination; the identification of economic, social, financial, environmental or other constraints which hamper the introduction of NRSE; and the mobilization of resources for national institutions dealing with research, training and information activities and programme formulation related to NRSE. Finally, the achievement of this objective can benefit from the mobilization of human, technical and financial resources for pre-investment and investment projects in the field of NRSE within global investment plans; the promotion of legislative measures and incentive policies to foster and promote the widespread use of NRSE; and the establishment of adequate pricing systems and appropriate allocation of resources for the different investment purposes.

Under the third objective, to establish concerted programmes to promote the wider use of NRSE which contribute to the achievement of over-all development objectives, several actions at the national level are proposed. These include the establishment and promotion of programmes to develop and employ methodologies for data collection and planning; strengthen research, development and demonstration activities in the field of NRSE, including the adaptation and testing of new technology; provide increased access to and application of proven and available new energy technologies; enhance the development and utilization of traditional and NRSE in the rural areas through integrated rural development programmes; train specialists for the exploitation and utilization of NRSE and for manufacture, operation, maintenance and repair activities; establish information networks; and promote research in the field of social and cultural constraints to the wider use of NRSE. At the regional level, programmes should be promoted through economic and technical co-operation among developing countries aimed at supporting national efforts to: develop methodologies for energy assessment and planning; establish information exchange networks; undertake research, development and demonstration including the establishment of regional testing and standards facilities; undertake training; and establish regional manufacturing facilities for the production of equipment.

Finally, the fourth objective is to mobilize regional and international resources to foster increased use of NRSE and to improve the effectiveness of existing activities. On the regional level, this would mean: the creation of regional institutions where appropriate to promote technical and economic co-operation in the field of NRSE; the mobilization of financial resources within regional institutions to promote pre-investment and investment activities on NRSE; the establishment of regional research centres in developing countries to promote self-reliance and technical co-operation among developing countries; and the promotion of multinational industrial programmes for the manufacturing of capital goods for NRSE. On the international level, this would require: mobilizing political support for the development of NRSE through its continued consideration by the political forums of the United Nations; co-ordinating co-operative efforts of international organizations; supporting existing programmes in international organizations and improving their effectiveness; and increasing the financial resources and revising the priorities of financial institutions and bilateral mechanisms aimed at additional support for concerted national, regional and international programmes in the field of NRSE, as well as the financing of demonstration, prototypes, pre-investment and investment activities, and financing investment activities for energy development in rural areas.

During discussion of the preliminary draft outline, there was general agreement about its soundness and usefulness as a working document. The difficulties presented by the multi-dimensional character of the theme were recognized and suggestions were made for improving the outline. The extensive suggestions presented by the delegation of Venezuela, on behalf of the Group of 77, included a proposal for reformulation of the list of objectives with the necessary changes in the action proposals to support this and the addition of a section on monitoring, follow-up, review and appraisal of the programme of action. The representatives of the United States and Japan also proposed substantial revisions, the former in reformulating the objectives of the programme of action and the latter in reordering the action proposals into separate categories for national, regional and international action. The delegation of the Netherlands, speaking on behalf of the European Community found that while restructuring of the outline as presented by the spokesman for the Group of 77 contained many of the same basic ideas with which the member states of the EC were in agreement, a small number of objectives would enable the Conference to focus its work on major issues, leading to effective and concrete action. Important contributions were made to the discussion by the delegations from the Soviet Union, particularly concerning the objectives, China, the German Democratic Republic, Canada, and Finland.

The Preparatory Committee requested that the Secretary-General of the Conference prepare, for consideration at the fourth session of the Committee, a preliminary draft of the programme of action, taking into account the preparatory work to date, including observations and proposals made during the third session of the Committee.

IV. PROVISIONAL AGENDA FOR THE UNCNRSE

Following discussion of the initial draft of the agenda for the Conference presented by the Secretariat, the Preparatory Committee approved the following agenda with the reservation that it will be reconsidered by the Committee at the fourth session in the light of developments in the draft programme of action:

- Opening of Conference
- Election of the President of the Conference
- Organizational and procedural matters
- General debate: NRSE in the context of development
- Consideration and adoption of the programme of action
- Adoption of the report of the Conference

V. DRAFT RULES OF PROCEDURE FOR THE CONFERENCE

The Preparatory Committee reached agreement on the draft rules of procedure for the Conference which will be presented to the Conference for adoption. Under these rules each participating State shall be represented by a head of delegation and no more than five other accredited representatives and such alternate representatives and advisers as may be required. The Conference shall elect a President, 23 Vice-Presidents and a Rapporteur-General, as well as a Chairman for each of the two main committees. Each main committee shall elect three Vice-Chairmen and a Rapporteur. Working groups may be established, if necessary, by the Conference and by the main committees. Other participants and observers to the Conference include representatives of the United Nations Council for Namibia, national liberation movements, specialized agencies, other intergovernmental organizations, interested UN organs and non-governmental organizations.

VI. PROVISIONAL AGENDA FOR THE FOURTH SESSION OF THE PREPARATORY COMMITTEE

At the request of the Chairman of the Preparatory Committee, the provisional agenda adopted by the Preparatory Committee for its fourth session was kept as short as possible to enable discussion to be focussed on the preliminary draft programme of action. Thus the provisional agenda for the session scheduled to be held in New York from 8 to 26 June lists three substantive items: preparations at the national level, the preliminary draft plan of action for adoption by the Conference, and the provisional agenda and organization of work of the Conference.

VII. OTHER MATTERS

Before adjourning, the Preparatory Committee requested the Secretary-General of the Conference to pursue the idea of establishing a computerized retrieval system of the compendium of existing studies on NRSE, to be provided to the Conference if extra-budgetary resources required could be secured.

In conclusion, the Secretary-General of the Conference drew attention to the need to give consideration at the fourth session of the Preparatory Committee to the organization of the work of the Conference to ensure that the scientific, technical and political aspects will all be adequately covered. He invited the views of Governments on this topic as well as on the programme of action and emphasized the need for help from Governments in moulding public opinion in support of NRSE.

NON-GOVERNMENTAL ORGANIZATIONS DEBATE NRSE ISSUES

The non-governmental organizations (NGOs) form a heterogeneous collection of non-profit institutions whose functions may include community development, promotion of public awareness and information, networking information gathering and analysis, philanthropy, research, education and training, and professional advocacy. What they have in common is that they represent organized expressions of the general will: expressions of the continued articulation and analysis of problems faced by individuals, families, and communities. On this account, NGOs can often anticipate new development issues well in advance of less-organically based governmental and international organizations.

Many NGOs are directly and actively concerned with NRSE as it relates to environment, development, youth and women's issues. Certain NGOs are repositories of much of the current technical knowledge and field experience on NRSE while others are engaged in development work for which energy issues have become paramount. All pointing to the critical role NGOs can play in the design and implementation of energy policies. Numbering over 1,000, they have been busy gearing up for participation in the UNCNRSE by assessing their activities in this field and getting together in a series of meetings held throughout the world which will culminate with the NGO Forum to be held in Nairobi at the same time as the UNCNRSE. The NGO Forum will include, as have many United Nations conferences in the past, the publication of a daily newspaper, exhibits, panel sessions and workshops, and above all, a schedule which will permit interaction with the delegations to the Conference itself.

Although these world-wide meetings are quite different in participation, organization and orientation, they show a remarkable similarity in substantive response. If the efforts of community groups - NGOs - can be co-ordinated effectively with the efforts of governments and intergovernmental organizations, the global energy transition on which the UNCNRSE is focused will be vastly facilitated. The following are brief summaries of three of these meetings, held in Tunis and New York.

I. ENERGY 2000

Organized by the International Youth Conference on the Human Environment, Energy 2000 was opened by the Prime Minister of Tunisia, Mr. Mohamed Mzali. It was attended by representatives of NGOs, UN and other international agencies, governments, professional associations, educational institutions and the media.

At the conclusion of the Energy 2000 Conference, the participants adopted a joint statement in the form of guidelines for an action plan which included, among other things, development of rational plans for use of energy resources, a redress of the imbalance in fuel consumption between the rural poor and urban industrial areas, and careful examination of the environmental, social and cultural impacts of any new energy sources. The Energy 2000 Plan also called for co-operation among NGOs stressing advocacy action at the national and international level, with priority given to transfer of technology both between North and South and between South and South. Specific mention was made of the need for biofuel plantations and biogas sources to meet the needs of the rural poor. Acknowledging the complexities of the problem and the different needs of different countries, the participants also called for special training programmes for youth, and suggested an annual Energy Day to maintain the momentum of the Conference.

The participants also adopted two resolutions, one underscoring the need for energy planning on the basis of "careful assessment of energy end-use, increasingly applying renewable energy resources to development needs appropriate to local conditions" and to consider the energy implications of all economic development to ensure more efficient and productive energy use. The second resolution expressed NGO disappointment at the inclusion of oil shale and tar sands on the UN Conference Agenda as essentially non-renewable.

II. NGO CONSULTATION

Smaller and more specialized than Energy 2000, the Consultation addressed itself exclusively to discussion of plans for specific action before, during and after the UNCNRSE in Nairobi. In this process, identifying issues that will be submitted as a draft position paper to the Conference Preparatory Committee at its Fourth Session meeting in New York from 8 to 26 June. The twenty participants in the Consultation were unanimous in their conviction that a "strong NGO presence" in Nairobi will be essential if follow-up activities are to be effective - and that this presence should also include close liaison with journalists covering the UNCNRSE so that the views of NGOs can be widely publicized.

In all, six issues were chosen for priority NGO attention. (1) The energy transition must be on a global scale in order to effect a long-lasting change from the present wasteful and inefficient system to the long-term, environmentally, socially and culturally sound use of energy resources. This would also have the effect of shifting political dependency for energy on any one nation or groups of nations. (2) Energy policy must be closely integrated with over-all development planning and objectives. (3) The industrialized countries must be encouraged to reduce their overwhelming energy demands, speed up their transition to renewable sources so that conventional sources may be diverted to the Third World to assist in its development. (4) Energy planning and the assessment of needs is essential, particularly in promoting a more equitable utilization of resources. (5) Special attention should be paid to the fuelwood crisis, with sufficient resources committed both nationally and from outside sources to restore fuelwood supplies to sustainable levels. (6) More public participation is needed in the decision-making process in order to deal with related issues such as those affecting women and young children.

Having identified these basic themes, the Consultation then went on to make specific recommendations for

NGO action at all levels. In the industrialized countries, for example, efforts should be directed at increased conservation and reduction in the use of fossil fuels and nuclear power, the development of new energy sources and technologies and the transfer of these technologies to other countries and to the underprivileged in their own countries. Transnational corporations, the largest of which are energy conglomerates with a bias towards high technology and the ability to dominate distribution, should be carefully monitored, possibly within the context of a code of conduct. Financing the energy transition should also be of major concern to NGOs since this is an area in which they might make suggestions as to sources of funds and how the funds might be spent. Environmental impacts of all energy sources should be carefully monitored and studied. Studies should also be made of the effects of military expenditures, both in terms of finance and energy use.

Both these meetings held in Tunisia in March 1981 had agendas which went beyond that of the UNCNRSE proper, and dealt with a broad scope of related issues, including the social, economic and political ramifications of making the necessary transition from a petroleum-dominated energy system to a long-lasting and sustainable mix of energy resources. Among the concerns voiced were the effect of energy issues on women and children, the chief procurers of energy in the developing countries, and the problem of growing fuelwood while at the same time cultivating badly needed food products.

III. NEW YORK NGO MEETING

An NGO meeting was held in New York on 8 April 1981 during the Third Session of the Preparatory Committee for UNCNRSE. The purposes in this meeting were: to stimulate public awareness and support of the United Nations' deliberations on NRSE; to help prepare the NGO community to make substantive contributions to the forthcoming UNCNRSE; and to initiate focused discussion on several areas, of particular concern to NGOs, on the subject of energy and development: women and energy, field problems and cultural constraints, education and training, environmental impact, energy conservation and efficiency, the role of multinationals, and North-South relations.

The following is a brief summary of the discussions and tentative recommendations in each area considered at the meeting.

1. Women and Energy

Inadequate or imbalanced energy-development programmes impact very severely on the economic well-being, health, employment, and cultural roles of women in developing countries, where they are major users of energy. Ironically, this well-known fact is often used as a rationale for treating women as representing adjustment problems instead of as critical resources in energy-development planning. It was tentatively recommended:

- that mechanisms be devised to support women in initiating and participating in training programmes that would facilitate their understanding of, and subsequent ability to analyse and evaluate, national and local energy planning;
- that an examination of the current and potential roles of women in energy development be taken up for discussion by the UNCNRSE;
- that every effort be made, both during the processes culminating in the UNCNRSE and in the deliberations that follow from it, to stress recognition of women as vital energy-development resources, end users, and economic producers who can make available energy serve expanding and changing needs, and who should be educated and consulted on issues concerning the procurement, production, and use of all sources of energy; and
- that the treatment of women's issues be included in a general integration of social, cultural and site-specific components of a policy process currently based largely on disparate technological, economic, and political considerations.

2. Field Problems and Cultural Constraints

Community energy decisions tend to be determined, not only by simple energy needs, but also by a plethora of economic, cultural, and social factors. The successful implementation of energy programmes at the community level, therefore, requires understanding of what these factors are and how they operate. It is tentatively suggested:

- that the UNCNRSE deliberations include special discussion of the social, economic, and cultural factors affecting field implementation of NRSE projects and that guidelines for taking these issues into account in policy formulation and programme design be drawn up;
- that the UNCNRSE make every effort to promote the view that field implementation of NRSE projects should be planned from the perspective of, and designed in consultation with, the users, since top-down efforts are seldom successful; and
- that the NGO community consider what institutional, economic, and training constraints it faces in the implementation of field projects and suggest specific policies and programmes to the UNCNRSE.

3. Environmental Assessment and Resource Management

Some NRSE will likely be found less damaging to the environment than conventional energy sources. Nevertheless, this is a hypothesis to be tested, not assumed *ab initio*; energy and the environment are intimately connected and cannot adequately be considered in isolation. It is tentatively recommended that:

- the UNCNRSE stress that policies on renewable energy sources exhibit clear understanding that biomass-related sources of energy do not, for the most part, regenerate of their own accord, but require management and planning;
- the UNCNRSE place special emphasis on training and deployment of resource managers and ecologists; and
- every effort be made to foster the view that natural resource management is an essential link between policy makers and the resource base in the policy-planning process.

4. Energy Efficiency and Conservation

Conservation of energy resources and the increased efficiency of their use might justly be considered as energy "resources" of the same importance as the supply options being considered by the UNCNRSE. The linkages between commercial energy sources, NRSE, and energy demand call for integrated approaches to policy making. It is tentatively suggested:

- that the UNCNRSE mandate be interpreted to pay more attention to management, particularly in the transportation and industrial sectors of developed-country economies;
- that efficiency and conservation be considered the equivalent of new sources of energy and that the promotion of efficiency and conservation be major policy recommendations of the UNCNRSE; and
- that those NGOs with expertise and experience in this subject area be consulted in the design and implementation of projects whose goal is to promote energy efficiency and conservation.

5. The Role of Multinational Corporations

There are several problematic issues related to the marketing of NRSE technologies by multinational corporations. Systems are sometimes sold without regard for potential inappropriateness; local manufacturers may be forced out by the competition; constraints may be placed on the transfer of knowledge, training, and technology; and there is a tendency for the multinational corporations to dominate the domestic industrial sector. On the other hand, the multinational corporations are in a unique position to contribute to the development of special kinds of NRSE, to increase support for, and delivery of, a broad spectrum of educational services, to provide technical advice, and to support and engage in needed information generation and dissemination. Moreover, many multinational corporations have significant expertise in implementing energy conservation and efficiency programmes both in industrialized and in developing countries. It is tentatively recommended:

- that the multinational corporations consider the needs and possibilities for training programmes on industrial energy efficiency and conservation practices, with emphasis on managerial and planning issues;
- that governments develop explicit policies towards multinational corporations and NRSE, perhaps including a focus on joint ventures and training;
- that the UNCNRSE consider what incentives might effectively promote innovation and technological diffusion with regard to NRSE by developing-country private sectors, and what measures might ensure mutually beneficial co-operation between those sectors and the multinational corporations; and
- that the NGO community provide a forum for discussion of these issues.

6. North-South Relations

It is essential to examine the role of NRSE in the transition from development based on low-cost petroleum to the context of a more varied spectrum of energy resources. However, this topic is intimately connected with some of the most fractious problems in North-South and South-South relations; it links the use of NRSE, an inherently intranational matter, with what is currently perhaps the most contentious of all international issues: the effect of the international petroleum market. In examining the energy transition, the UNCNRSE has opened the door to debate on the impact of energy consumption in OECD countries on petroleum prices and supplies in the oil-importing South; the developmental role of OPEC agencies; and the regional economic and political role to be played in NRSE assistance by local petroleum exporters. All of these issues are further related to difficulties faced by the Global Negotiations and other international fora. There is a danger in this. Attention might be diverted away from the developmental aspects of NRSE and fixed on liquid-fuel and electricity-generation options. It is therefore tentatively recommended:

- that the NGO community, which can discuss and debate politically-charged issues in a manner unavailable to governments, focus attention on the difficult international issues related to the energy transition;
- that NGOs with the necessary expertise, particularly those in the developing world, discuss the role of NRSE in broader international issues and with regard to such fora as the Global Negotiations; and
- that a concerted effort be made by NGOs to solicit and publicize views on the energy transition from a wide range of perspectives, and to work with other groups discussing the Global Negotiations, the NIEO, the Brandt Commission Report, and other related issues.

7. Education and Training

NRSE training, a process for developing practical skills, should be designed to capitalize on or develop employment opportunities for its graduates and evaluated in part by how well it succeeds. NRSE education, a process for transmission of information and conceptual development, should be geared not only to the production of technicians, but also to policy planners and extension workers, and should be imparted to individuals from a wide range of disciplines, not just those directly related to energy. Necessary support systems for education and training, especially information-transfer systems, should be considered integral, and should be planned and budgeted carefully and financed accordingly. Finally, training and educational programmes should promote an integrated perspective of the technical, economic, political, cultural, and social factors that affect NRSE development. It is therefore tentatively recommended:

- that first emphasis be placed on local training programmes that produce income-earning skills;
- that centralized training centres be reserved for the training of trainers or for field workers who

will be working in other than their local context;

- that efforts be made to promote curricular changes in local schools and universities that introduce energy considerations into every discipline, as appropriate;

- that the most careful attention be paid to the difficulties of financing education and training, including financing information transfer, and that innovative solutions be sought;

- that support for information transfer not be restricted to research and development, but that funding also be allocated as needed for publishing, translation, use of audio-visual materials and microforms, provision of on-line services, strengthening of libraries, and distributing information readily, affordably, and as widely as possible; and

- that NRSE education and training be considered inherently interdisciplinary and that programmes be designed to take account, locally or generally as appropriate, all the intersectoral considerations the subject encompasses.

UNESCO ORGANIZES MEETING ON NON-TECHNICAL OBSTACLES TO NRSE USE

The 456th Bellagio Conference was held at the Rockefeller Foundation Study and Conference Centre in Bellagio, Lake Como, Italy, 25-29 May 1981 to consider Non-Technical Obstacles to the Use of New Energies in Developing Countries. Twenty-five international specialists met under the aegis of UNESCO with the sponsorship and support of nine organizations working in the energy field including: the Center for Integrative Development (CID), the Commissariat à l'Energie Solaire (COMES-France), the Commission of the European Communities (CEC), the Commonwealth Science Council (CSC), the International Development Research Centre (IDRC), the Rockefeller Foundation, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations University (UNU), and the United States Department of Energy (USDOE). In reviewing the subject the following general points were noted:

- Current energy supply patterns can be expected to change significantly over the next two decades, with an increasing use of what are termed "new and renewable" sources of energy. Within this pattern, however, fuelwood and other traditional organic fuels are likely to continue to be dominant in rural areas in the short- and medium-term future.

- New and renewable energies vary greatly in technical refinement, inherent complexity, potential applications, costs and other factors, each facing different obstacles to use. Thus they cannot be considered as a discrete and homogeneous group of technologies.

- New and renewable energy sources must be considered in the light of the whole energy problem facing the world, and it should be recognized that they will contribute to the future energy supply in both industrialized and developing countries.

In its deliberations on major non-technical constraints in developing countries, the group focused on education, information, social and cultural, and institutional factors. These constraints warrant special attention at this time, since it appears that the opportunities to promote their positive rather than negative influences are greater than in the case of constraints of a more economic and financial nature. Beyond this, it was noted that the limitations imposed by time, including not only lead-time to develop facilities but also lead-time to prepare the human and physical infrastructure to accept change, is often neglected.

In its discussion, the group highlighted the following points:

- Education and training programmes are required over a wide range, covering not only schools and universities but also training of policy makers, planners, managers and extension workers, as well as the general public, including the rural and urban poor, both men and women. Attention should be paid to assessment of education and training needs on a country-by-country basis and the capabilities of local institutions which must be strengthened to meet these needs.

- Promoting new energy use requires improvement of information facilities and services, with emphasis on generation of reliable and relevant information, and its dissemination to those who can act upon it. Basic technical and economic data (e.g. physical parameters, design specifications, maintenance routines) frequently do not exist in usable form, and practical measures to help generate such information were identified. Particular attention should be given to generation and analysis of comparable data on installation, operation and maintenance experience, including not only technical data but also case studies on non-technical issues.

- The impact of change in the energy mix on all societies and cultures involving introduction of new sources is not well understood. In less developed countries, many social and cultural constraints are intimately linked to the problems of poverty. The delicate balance of survival strategies makes risk-taking on new technologies quite difficult, a factor which needs greater emphasis in planning and implementation procedures. Special care must be taken in development programmes (afforestation, stove design, alternative cooking fuels such as biogas) to avoid misunderstandings and possible negative rather than positive impact. It is important to distinguish among groups within the society so that technologies can be selected and adapted to the needs of the people who will use them (men, women, urban, rural, poor, landlords). Cultural attitudes which favour energy-intensive approaches (e.g., large automobiles or climate-controlled architecture) also impede the adoption of new technologies. Alternative life styles which are less energy consuming are needed both in developed and developing countries. Cultural and social values must not be viewed only as constraints, but also must be built upon in the search for alternative development patterns which are less reliant on today's commercial fuels.

- In considering the institutional framework for the application of new sources of energy in developing countries it must be recognized that structures tend to favour the urban and commercial sector, while major needs may be in the rural and traditional sector. An appropriate institutional framework for planning, policy making and co-ordination might envisage a national focal point for development of new and renewable sources of energy with responsibility for ensuring that adequate resources are devoted to such basic functions as resource assessment, research and development planning and promotion, investment promotion and monitoring and evaluation. The precise role of the focal point would be expected to vary from country to country, depending on national circumstances. Institutional support for new and renewable sources on a small-scale decentralized basis may require special attention as it does not fit most existing patterns.

Dealing effectively with this wide range of problems requires a highly integrated approach within which they can be considered in relation to one another as well as to the full cross-section of countries and peoples of the world, with a degree of emphasis on the needs of the poor and disadvantaged.

The United Nations Conference on New and Renewable Sources of Energy can provide the occasion to highlight these problems and to provide guidelines for a Plan of Action which can lead to a greatly improved situation, recognizing that follow-up will require the concerted efforts of the full range of inter-governmental, governmental and non-governmental organizations working in related fields.

NATIONAL FOCAL POINTS FOR UNCNRSE
(UPDATED)

CORRIGENDA

BARBADOS

Ministry of Caribbean Affairs,
External Trade, Industry and Tourism
Reef Road, Fontabelle
St. Michael

JORDAN (HASHEMITE KINGDOM)

Department of Energy
Ministry of Industry and Trade
Amman

KENYA

Mr. W.E. Hiribae
Deputy Secretary
Ministry of Energy
P.O. Box 30582
Nairobi

and Mr. P.J. Ndung'u
Ministry of Foreign Affairs
P.O. Box 30551, Nairobi
Tel.: 334433
Cable: "FOREIGN NAIROBI"

SAINT LUCIA

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Savezni Komitet za Industriju i
energetiku
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Bulevar AVNOJ-a 104
11070 Novi Beograd

and

Savezni sekretarijat za inostrane
poslove (Federal Secretariat for
Foreign Affairs)
Uprava za ekonomske odnose
Kneza Milosa 24
11000 Beograd

The UNCNRSE Conference News section of ASSET is edited by Mary Esther Leung, UNU, New York, with the support of the ASSET editorial assistant, Yoko Doi, UNU, Tokyo.

Experimental and computational studies of a full-scale heat-storage system with salt hydrate as the storage medium and based on the extra-water principle are reported. Two different types of full-scale heat-storage systems, both making use of an incongruently melting salt hydrate as a storage medium and based on the extra-water principle, were examined by means of long-term experiments. In the first heat-storage type, oil as a heat-transfer fluid in direct contact with the storage medium was used. The second storage type was a mantle storage where water as the heat-transfer fluid was circulated in the mantle. No decrease in the performance of the storages during the long-term experiments was observed, and experiences for both storage types are obtained. By means of computer calculations, heat-of-fusion storage with oil as the heat-transfer fluid in direct contact with the storage medium were compared with hot-water storage as part of solar-heating systems with the Danish reference year as a basis. With results of these calculations, examples of economical comparisons between heat of fusion storage and hot-water storages are carried out. Considerations and experiments concerning storage material, stability of heat storage, and heat-transfer capacity are carried out.

411/81 STUDY OF THERMAL ENERGY STORAGE BASED ON FUSION OF ORGANIC MATERIALS (ETUDE DU STOCKAGE DE L'ENERGIE THERMIQUE PAR FUSION DES MATERIAUX ORGANIQUES). P. Dubois and B. Hochon (Centre de Recherche, Cie Générale d'Electricité, Marcoussis 505-515 (France)). New Ways to Save Energy (Proceedings of the International Symposium, held Brussels, Belgium, 1979). Reidel, Dordrecht, Netherlands (1980).

This study covers the physical chemistry of phase-change materials and the phenomena of storage and recovery cycling. Energy storage for houses is also considered. 5 refs.

Cette étude traite des aspects physico-chimiques des changements de phase, les phénomènes de cycles stockages-reprises, ainsi que le stockage d'énergie pour les locaux d'habitation. 5 réf.

F. SOCIO-ECONOMIC ASPECTS

412/81 FOOD VERSUS FUEL: COMPETING USES FOR CROPLAND. L. Brown. Environment, vol. 22, no. 4, p. 32-40 (May 1980).

Agriculturally based alcohol-fuel programmes in food-exporting countries will become international issues as land is converted from food to fuel crops and the affluent world minority increases its demands for power at the expense of the poor. Brazil is the current leader in fuel crops, followed by the USA, South Africa, New Zealand, Australia, and a number of developing countries. The effect this is having on per capita grain production is reflected in the decline of world cropland and the increase in food prices. The shift to massive energy crops will have social and political ramifications as countries weigh the environmental and economic attractions of alcohol fuels against the pressures they place on food production. The steps that could minimize the potentially adverse effects of fuel crops include careful international planning to warn food-importing countries, arrest the erosion of topsoil, and a food-pricing monitoring system. 30 refs.

413/81 UTILIZATION OF SMALL-SCALE SOLAR ENERGY FOR RURAL DEVELOPMENT: A STRATEGY. B. Prakash (Birla Institute of Technology and Science, Pilani (India)). P. 722-34 of Proceedings of the National Solar Energy Convention of Solar Energy Society of India (held Bhavnagar, India, 22-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

The scope for utilizing solar energy for rural development is immense and so is the need to understand the village environment in terms of life style, resources, and technology. A strategic research plan can work only if it exhibits sound awareness of impact and long-term consequences of the introduced technology with respect to sociological, economical, and ecological balances. Apart from education and training, the efforts and involvement of large-scale institutions and organizations would contribute considerably in such developmental efforts.

414/81 COMPARISON OF COSTS FOR SOLAR ELECTRIC SOURCES WITH DIESEL GENERATORS IN REMOTE LOCATIONS. F.K. Manasse (Aetna Corp., Dover, DE (USA)). P. 162-77 of Proceedings of the First Solar Power Generation Conference (held San Jose, CA, USA, 1979).

A comparison is made of the costs of electricity in remote locations using solar-thermal and -photovoltaic systems and using diesel-motor units from 10 - 20 kW_e. 6 refs.

415/81 PHOTOVOLTAIC POWER SYSTEMS MARKET IDENTIFICATION AND ANALYSIS. VOLUME II (OF 2 VOLUMES) (BDM Corp. McLean, VA (USA)). HCP/M2533-01/2 (Nov. 1978). 276p. NTIS. US$18.50.

The following subjects are covered: the present world-wide market for photovoltaic power systems, the potential applications of photovoltaic power systems, an approach for generating product-market scenarios, product-market scenarios for photovoltaic powered street and highway lighting, irrigation pumping systems, and a product-market scenario for applications in a village in India.

SELECTED ARTICLE

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RENEWABLE RESOURCES (HYDROCARBONS)

by

D. O. Hall
Department of Plant Sciences, University of London King's College
68 Half Moon Lane, London SE24 9JF, UK

About half of the world's present energy consumption is based on petroleum, some 65 million barrels of oil per day. Decisions made in the 1950s and 1960s have locked the world into a primarily oil-based economy for at least the next twenty years, the time it would take to make a significant change of direction in energy-use patterns. The production of oil has been static at about 22 billion barrels per year for the last two or three years and most expectations are that it will remain at this level or, more probably, decrease from now on due, not to technical reasons or physical limitations but, primarily, as a result of politico-economic decisions.

Realization of the increasing real cost and decreasing availability of petroleum has stimulated a search for alternative fuels – especially for liquid fuels to power transport facilities. Hence the large programmes in Brazil and the USA for the production of ethanol from carbohydrate crops (sugarcane, sugar beet, cassava, sorghum, grains, etc.) and the schemes in Canada, New Zealand, Europe, the USA and Brazil for methanol production from forest or plantation trees.

Opportunities for decreasing imported oil costs and saving foreign currency, creating local employment, stimulating domestic technology and decreasing air pollution, however, must be weighed against land, food and agronomic requirements, economic costs and the attainment of net energy benefits (Hall 1979, 1980).

Many species of plants produce hydrocarbons which can be used as fuels and chemicals; probably the best known is natural rubber from the cultivated tree *Hevea brasiliensis.* Such hydrocarbons are chemically more reduced than carbohydrates, and can be used directly rather than, as is necessary with carbohydrates, after a microbiological or thermochemical conversion.

Currently, serious efforts are being made to select and establish trial plantations of plants which produce hydrocarbons of lower molecular weight than rubber with the aim of extracting liquids which will have properties very close to those of petroleum.

Systematic searches for species of plants with high hydrocarbon content have been made sporadically in the past. In 1921 Hall and Long published a monograph on the 'rubber' content of N American plants and, in the four years before his death in 1932, the American inventor Thomas Edison examined about 2,000 plants; he found many hydrocarbon-containing species, but only one or two in which the molecular weight of the hydrocarbon was large enough to be considered as a possible candidate for substitution for natural (*Hevea*) rubber. Such screening efforts have generally been directed towards latex-producing plants, since latex, a milky emulsion of about 30% hydrocarbons, is the raw material of cultivated natural rubber. However, many species of plants, particularly in the family Euphorbiaceae, produce in their latex hydrocarbons with much lower molecular weights than rubber (10 to 20,000 rather than 1 to 2,000,000) and it is these molecular weight products which are now being sought as 'oils'.

In the genus *Euphorbia,* almost every species is a latex-producing plant; the latex of about a dozen species of *Euphorbia* has now been analysed, and most samples contain hydrocarbons of a much lower molecular weight than those of rubber.

The reduced organic materials (those extractable by acetone and benzene) average 10(±5)%. From the value of 10% oil content, a rough calculation has been made (Calvin 1976): for biomass production an annual yield per acre of 10 tons (dry) can reasonably be expected, giving an oil production of 1 ton (7 barrels). Annual cultivation costs per acre were estimated to be $150, or about $20 per barrel. Processing costs were not included, but neither was the value of the residual biomass. The possible added value of the oil for uses other than fuel has yet to be determined. This preliminary cost estimate was, then, close enough to the current price of petroleum to warrant further investigation.

The question of whether there is a net energy benefit from such an enterprise, i.e. the energy output:input ratio is greater than one, has apparently not been resolved as yet. The by-products may have monetary values and energy contents which could change the picture significantly.

Calvin later (1979) concluded that this type of exploration gives rise to two practical approaches to renewable resources:

- To use the hydrocarbon as it comes from the plant itself as a crude oil, refine it, remove the sterols which it contains, crack the rest of the compounds to ethylene, propylene, etc., and then reconstruct other chemicals from those products; this approach can be developed immediately:
- To learn how the molecular weight is controlled and to manipulate the plant to construct materials of the desired molecular weight, an approach which will be

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Table I
Oil and hydrocarbon crop models, yield and composition to be taken as specifications for new crops.*

Component	Rubber crop		Oil plus byproduct rubber crop		Oil crop		Gutta crop	
	Yield kg/ha/yr	Composition dry basis %	Yield kg/ha/yr	Composition dry basis %	Yield kg/ha/yr	Composition dry basis %	Yield kg/ha/yr	Composition dry basis %
Total dry matter	13,500	100	17,900	100	22,500	100	11,500	100
Crude protein	1,485	11	1,610	9	1,350	6	1,150	10
Rubber	1,350	10	360	2	—	—	—	—
Gutta	—	—	—	—	—	—	1,380	12
Oil	810	6	2,150	12	2,250	10	920	8
Polyphenol	945	7	1,250	7	4,050	18	805	7
Extracted residue†	10,395	77	14,140	79	16,200	72	8,395	73

*Yields are based on harvesting and using the entire aerial plant.
†Assuming little or no protein is extracted with the other components.
Source: Buchanan & Otey 1979

longer and more complex, using the plant as the collecting and constructing vehicle.

At the USDA research laboratories in Peoria, Illinois, Buchanan & Otey (1979) have recently evaluated some 300 plant species, and developed a scenario for the introduction of new oil and hydrocarbon-producing crops into the USA agricultural scene. They concluded that, for practical agricultural production of hydrocarbons and natural rubber in the United States, highly productive plant species adaptable to USA situations must be identified and selected for genetic improvement. The selection should be made from the viewpoint of entire-plant utilization for fibre, protein, and carbohydrate. Thus, procedures and criteria have been established for the preliminary evaluation of plant species as potential multi-use hydrocarbon-producing crops, and it may be envisaged that, for oil- and hydrocarbon-producing crops, primary processing factories ('botanochemical factories') might be situated to handle crops grown within a 25 km radius. Each factory would process 280,000 to 550,000 t/yr of whole-plant produce grown on about 24,500 ha of crop land. The product mix could be adapted to changing economic or social needs; possible primary products might include whole-plant oils, soluble polyphenols, rubber, gutta rubber, cattle feed, high-protein feeds and food supplements, paper-making fibre, glucose, xylose, fuel alcohols, methane and soil-amendment chemicals.

These authors anticipate that a 50% improvement in dry-matter yield and a two- to threefold increase in oil and hydrocarbon content should be possible during domestication. Such projected increases in yields seem justified in view of past accomplishments by plant breeders and agronomists working on conventional crops such as *Hevea,* but they must produce at least 2 tonnes/ha per year of oil plus hydrocarbon to be comparable with *Hevea.*

A few of the large number of species examined were selected for more detailed studies as potential rubber crops (13 spp.), potential oil + rubber crops (11 spp.), oil crops (9 spp.) and gutta rubber crops (3 spp.). Table I shows theoretical values for yield and composition and indicates desired specifications for new crops. The data in Table I were used to calculate the yield and economics of the enterprises (Table II).

The rubber crop model is a herbaceous perennial such as might be developed from mountain mint, *Pycanthemum incanum,* pale Indian plant, *Cacalia atriplicifolia,* or milkweed, *Asclepias syriaca.* The oil-plus-byproduct-rubber crop is also a herbaceous perennial, such as might be developed from tall bellflower, *Campanula americana, Eupatorium altissimum, Sonchus arvensis* or *Silphium* spp. The oil crop model is a woody perennial coppice (short rotation forestry) crop, high in polyphenol content, such as might be derived from silver maple, *Acer saccharinum, Rhus glabra* or sassafras, *Sassafras albidium.* The gutta crop is to be developed from a perennial grass, e.g. wild rye, *Elymus canadensis,* Canary grass, *Phalaris canariensis,* or quack grass, *Agropyron repens.*

Other species which are better known are also included, e.g. guayule, *Parthenium argentatum*, Russian

Table II
*Botanochemical processing, scale, and product value**

	Rubber crop	Oil plus byproduct-rubber crop	Oil crop	Gutta crop
Feedstock, 10^3 t/yr	330·80	438·60	551·30	281·80
Products and returns:				
Rubber, 10^3 t/yr	33·08	8·77	—	—
Rubber, $\$10^6$/yr	29·77	7·89	—	—
Gutta, 10^3 t/yr	—	—	—	33·81
Gutta, $\$10^6$/yr	—	—	—	22·31
Oil, 10^3 t/yr	19·85	52·63	55·13	22·54
Oil, $\$10^6$/yr	3·28	8·68	9·10	3·72
Polyphenol, 10^3 t/yr	23·16	30·70	99·23	19·73
Polyphenol, $\$10^6$/yr	1·92	2·55	8·24	1·64
Residue, 10^3 t/yr	254·70	346·50	396·90	205·70
Residue, $\$10^6$/yr	7·13	9·70	11·11	5·76
Total return, $\$10^6$/yr	42·10	28·82	28·45	33·43
Return, $/ha/yr	1718·00	1176·00	1161·00	1364·00

*Based on May 1978 prices as follows: Natural rubber $0·41/lb ($0·90/kg), whole-plant oils as crude tall oil at $150/ton ($165/t), gutta as general purpose polypropylene at $0·30/lb ($0·66/kg), polyphenols estimated value $75/ton ($83/t) and residue estimated value $25/ton ($28/t).
Source: Buchanan & Otey 1979

dandelion, *Taraxacum kok-saghyz,* Edison's goldenrod, *Solidago leavenworthii, Euphorbia dentata* and *E. heterophylla.*

Research efforts to date have centred on identifying and characterizing plant species that have potential as new oil and hydrocarbon crops and need to be greatly expanded and followed by a significant programme of plant breeding, genetic and agronomic studies. Natural rubber can be produced from the desert shrub guayule and large quantities have been so produced in the past; because much of the research needed to make guayule a practical proposition was done by the USDA during World War II, it is currently the most viable possibility as a multi-use oil and hydrocarbon crop. Guayule research however has a more general applicability and it is especially important for its contribution to the long-term objective of producing hydrocarbons from new types of plants.

Desert covers about 30% of the land area of the world. There are, also, large semi-desert areas and arid savannas, and it has become increasingly evident that these could be important local sources of various types of organic chemicals. In general, the type of research and development required has been sadly neglected, and attempts to integrate such regions into the general economic development have always remained outside the plans of any government or international organization. There is now a pressing need to rescue the deserts, to preserve their ecological characteristics and to use them in the search for plants, renewable sources of industrial materials and chemical products which would not be produced in regions with a potential for food production.

An important exception to this story of neglect has been the efforts of the CIQA Research Institute in Saltillo, Mexico, and the Office of Arid Lands Studies, University of Arizona, Tucson (Campos-Lopez & Roman-Alemany 1980, Johnson & Hinman 1980). The area covered by these two Institutes is the Chihuahuan Desert which covers some half million square km on both sides of the USA/Mexico border at an altitude of 900–2,000 m.

Experience in the handling, use and even improvement of some of the plants originating in the Chihuahuan Desert is abundant. In addition to guayule, industrial materials produced from Chihuahuan Desert plants include Candelilla wax from *Euphorbia antisyphilitica,* oil from jojoba, *Simmondsia chinensis,* and Ixtle – the generic name for hard fibres obtained from *Agave lecheguilla* and *Yucca carnerosana,* which are still principal sources of employment in the region. Such materials are or were produced to be exported but, for local consumption, there are numerous fuel shrubs such as mesquite, *Prosopis juliflora,* and some plants with food value, such as prickly pear, *Opuntia streptacantha,* and nopal, *Opuntia* spp.; in fact, there is an abundant flora made up of at least 100 families with 566 genera and about 1,500 species, the most important of which are indicated in Table III.

Since only qualitative phytochemical information is available, applications for desert plants are frequently proposed without reference to either the requirements or limitations of industry. Nevertheless, numerous organic compounds have been identified and many have been used for practical purposes. These include antibiotics, steroids, and other pharmacological products, insecticides and fungicides, cosmetics, soaps and detergents, organic coatings, plastics and elastomer additives, antioxidants, dyes and tannins, in addition to the food, fuel and fibres which support humans and animals.

It is important to understand the chemistry and economics of rubber from *Hevea* and guayule since these are well established crops whose selection and agronomic characteristics are comparable to those which may be required from future hydrocarbon plants.

Rubber *(Hevea brasiliensis)*

Since rubber is the most important hydrocarbon harvested from plants it needs to be dealt with in some detail to show how plants can be used as a source of renewable hydrocarbons. At present about five million tons of *Hevea* natural rubber enter world trade each year with a value of over $5,000 million – this is about a third of the world's total use of rubber, the remainder being synthe-

Table III
Principal plant families of the Chihuahuan Desert

Family	No. of species
Amaryllidaceae Most important genus: *Agave.* Hard fibre is obtained from *Agave lecheguilla*	26
Liliaceae Most important genus: *Yucca.* Fibre is obtained from *Yucca carnerosana* and steroids from *Yucca filifera*	42
Cactaceae Most important genus: *Opuntia.* Food consumption; contains alkaloids, sugars, gums, pigments.	98
Euphorbiaceae Most important genus: *Euphorbia.* Candelilla wax is obtained from *Euphorbia antisyphilitica*	46
Leguminosae Most important genera: *Prosopis* and *Acacia.* Contain alkaloids, proteins, tannins, and essential oils	105
Cruciferae Most important genus: *Lesquerella.* Contains a high percentage of oil in the seeds	15
Solanaceae Most important genus: *Datura.* Contains alkaloids.	25
Compositae Most important genus: *Parthenium.* Rubber is obtained from *Parthenium argentatum*	182
Gramineae Its species form the pastures; used both green and dry, to feed cattle	386
Zygophyllaceae Most important genus: *Larrea.* A resin containing an antioxidant, flavonoids, and lignins is obtained from *Larrea tridentata*	6

After Campos-Lopez & Román-Alemany (1980) tic rubber derived from petroleum.

Rubber is a polyisoprenoid, the formation of which is confined to the latex of about 300 genera of dicotyledonous Angiosperms; it does not occur in monocotyledons, Gymnosperms, or lower plants. Some 1,800 species of higher plants have been shown to contain polyisoprene, but in most cases the amount present is small. Only *Hevea brasiliensis* is grown commercially and produces around 1,500 lb of rubber per acre (1·7t/ha) per year.

Commercially, rubber is propagated either from seed or vegetatively by budding selected clones onto seedling rootstocks. The striking of cuttings is difficult, but recent work (Chen *et al.* 1979) claims to have produced complete plants from pollen grains.

Although the average yield of rubber per tree per tapping has increased over fivefold, from about 13 g in 1927 to some 65 g in 1975 (Archer 1980), the main impediment to the breeding of improved clones has been the lengthy period involved – some 25 years from cross-pollination of the parent flowers, through all the stages of propagation of sufficient clonal material, assessment for yield, disease resistance, etc., to commercial latex production.

Nevertheless, plant breeders have apparently bred out to a great extent the regulatory mechanism which controls the channelling of 'photosynthate' into rubber, so that far more is synthesized than would be produced in normal strains or in other rubber-synthesizing Angiosperms and, recently, the use of 2-chloroethylphosphonic acid (ethephon) which decomposes to ethylene in neutral or alkaline solution has been found to stimulate the flow of latex (Dickenson 1976) and is now widely used commercially.

Such practices have raised productivity to almost 2,000 lb/ac (2·2 t/ha) per year in Malaysian rubber plantations. There are, in fact, small experimental plots of *Hevea* which produce 4,000 lb/ac per year, and individual trees can produce (when extrapolated to plantation size) 8,000 lb/ac per year (Calvin 1980). This is equivalent to four tons of hydrocarbons. Since one ton of hydrocarbon is the equivalent of about 7 barrels of oil, this means that, theoretically, the equivalent of some 25 barrels of oil/ac might be obtained per year.

The latex in which rubber is found is a hydrosol containing about one-third hydrocarbon. Polyisoprene occurs as minute particles which often, but not invariably, form the disperse phase of this latex. Several plants contain latex but no polyisoprene, and in these the disperse phase is commonly some other type of isoprenoid material (e.g. essential oils, balsams, or resins). *Hevea* latex is contained in specialized cells or series of fused cells known as laticifers. These structures are usually tubular and may be branched and it is the possession of this system that enables rubber to be collected by 'tapping'. There is no evidence that polyisoprenes have any biological function whatsoever, and they are probably best regarded as inert end-products of metabolism (Archer 1980).

Pure rubber is a *cis*-1,4-polyisoprene $(C_5H_8)_n$ of high molecular weight (about 2 million from *Hevea*), but the commercial raw material contains a wide range of impurities, some advantageous and some disadvantageous to the user. Gutta, obtained mainly from *Palaquium gutta,* which used to be used extensively for cable insulation, belting and golf-ball covers, is a *trans*-1,4-polyisoprene of lower molecular weight than rubber, while chicle, the basis of chewing gum, is a mixture of relatively low molecular weight *cis*- and *trans*-polyisoprenes and is obtained from sapodilla, *Achras sapota.*

The biological isoprene unit, isopentenyl pyrophosphate (IPP), from which all terpenoids appear to be synthesized, is formed from three molecules of acetyl-Coenzyme A via mevalonic acid. Successive stages in the biosynthesis of terpenoids are shown in Figure 1.

The extension of the chain of the rubber polymer takes place in a particulate fraction of the latex. The final stages in the biosynthesis are essential for the *in vitro* formation of polyisoprene. It has been shown that an enzyme (rubber transferase) is present in the serum, but that it remains inactive until adsorbed. The reaction appears to be predominantly a chain extension process involving existing rubber chains, which presumably

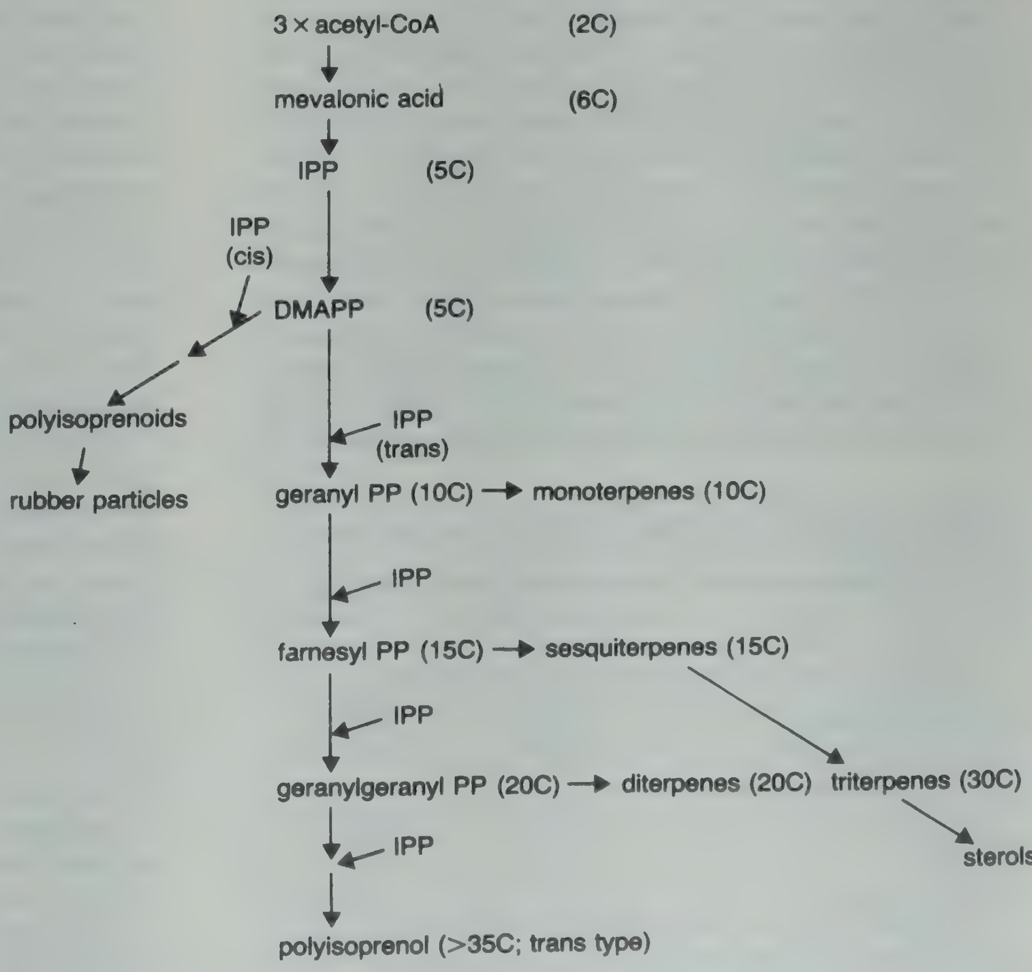

Figure 1 Biochemical pathways to terpenoids.

carry acid-labile allyl pyrophosphate end-groups. All other factors necessary for rubber synthesis like CoA, sugars, minerals, ATP, NADPH, enzymes, etc., must be present in the latex.

The rubber and sterol contents of latex from a number of plants are shown in Table IV.

The main reason why only one species, *Hevea brasiliensis,* has so far become commercially established is that a high yield of technologically-acceptable raw material can be obtained over many years by simple excision of the trunk bark of mature trees, made at frequent intervals. *Castilla elastica* (Panama rubber) can be tapped only a few times per year because the latex is replenished slowly; more frequent collection can be made from the rubber vine, *Cryptostegia grandiflora,* but from thin stems ('whips') which yield little latex. To obtain rubber from *Parthenium argentatum* (guayule) or *Taraxacum kok-saghyz* (Russian dandelion) it is necessary to macerate the tissues.

Guayule rubber

Guayule *(Parthenium argentatum)* is native to the semi-arid regions of north-central Mexico and southern Texas where it is scattered over a 130,000 square mile plateau. Like all arid region plants it needs a great deal of sunlight and low night temperatures; it is, however, one arid plant that has been cultivated as much in as out of its normal habitat (Anon. 1978, Campos-Lopez 1979).

A two-year-plant normally produces some 10% rubber by dry weight; some varieties yield as much as 25% and, with chemical stimulants, rubber production can be increased at early stages of growth to 30%. Guayule rubber is found not in a specialized lactifer system, but in the parenchyma of stems and roots as latex particles similar in size to those obtained from *Hevea.* For this reason it cannot be 'tapped' but must be extracted from the tissues, and because it contains no natural antioxidant it degrades rapidly in contact with air, so the plant must be processed within a few days of harvesting.

In the early part of the century many prominent Mexican and American industrialists were associated with the development of guayule, but the amount of rubber produced, mostly by Mexican mills, varied widely over the years. Starting with 750,000 lb in 1905, it reached a maximum of more than 21 million lb in 1910 from 14 factories, providing 10% of the world's rubber and 50% of USA consumption. It dropped to a low of 65,000 lb in 1921, but again increased to a peak of about 12 million lb in 1927, when the British government restricted the sale of rubber from Malayan plantations. After a drop in the early 1930s because of low rubber prices, production increased to a peak of nearly 20 million lb in 1944, practically all of which was shipped to the United States. Production in the United States included a small amount from a mill at Marathon, Texas, and rubber from plantations of the Intercontinental Rubber Company near Salinas, California.

Table IV
Hydrocarbons and sterols from latex of various plants, expressed as % dry wt of latex

Source	Rubber %	Sterols %
Achras sapota	14*	66
Asclepias sp. (Brazil)	3·5	31
Asclepias sp. (USA)	12	72
Euphorbia coreulescens	1	75
E. lathyris	3	50
E. tirucalli	1	50
E. trigona	1·5	75
Hevea brasiliensis	87	1

*30% *cis-* and 70% *trans*-polyisoprene.
Other samples all *cis*-polyisoprene.
After Nielsen *et al.* (1977)

In 1942 following the loss of some 90% of the rubber supply to the Japanese forces in SE Asia, the Emergency Rubber Project started in the USA with a reconnaissance survey of some 32 million acres of land and the classification of over 5 million acres for guayule culture. Land acquisition was intensified and some 60,000 acres were leased. Because of later curtailment of the Project, the planting goal was never reached and, in the end, only 32,000 acres were planted, but a great deal of expertise was acquired.

Temperatures below 16°C were considered unsuitable (below 4°C the plant becomes dormant). A mean annual rainfall of 11–25 in. (280–640 mm) was considered suitable; below 11 in. supplementary water was necessary for a worthwhile yield, while above 25 in. excessive vegetative growth occurred. Records during the life of the Project showed that these estimates were not too far off.

Although a desert plant, guayule shows marked response to a plentiful moisture supply so long as good drainage and aeration of the soil are maintained. It responds to warmth and is tolerant of high temperatures. These growth characteristics were found to be true for nursery seedlings as well as field plantations. Irrigation was tried to shorten the growth cycle; it was decided that the quantity of irrigation water available would need to be adequate for forcing growth in a two-year growing period. In the event the amount was less than at first had been believed; experimental projects indicated that guayule could be grown successfully on many lands where the supply of irrigation water was insufficient for the successful production of most agricultural crops.

Actively-growing guayule produces little rubber, but there is a gradual build-up of rubber in the plant during the semi-dormant or non-growing season. While all the factors which bring about this seasonal acceleration in rubber deposition are not yet known, it appears that the phenomenon is induced both by cool temperatures and high moisture stress. On resumption of active growth, the rubber produced is not metabolized, and remains in the plant tissues.

By the time the Emergency Rubber Project was terminated, over 5 million acres had been classified as to suitability for guayule production in California, Arizona, New Mexico and Texas. Over a million pounds of seeds had been collected, 2,000 acres of nurseries had been planted, over 500 million seedlings dug, culled, packed, and shipped from the nurseries. Thirty-one thousand acres had been planted in California, 200 in

Arizona, and 400 in Texas, and 3 million lb of rubber produced.

But in 1946, on the return to peace-time conditions which included a by-now highly competitive synthetic elastomer industry, all guayule plantations were ordered to be destroyed and the land turned back to the owners, 85% of the shrub that had been grown on the land was unharvested resulting in the destruction of 21 million lb of rubber. Also during the liquidation period, two mills for the extraction of rubber, various laboratories, and other buildings were disposed of.

Though many countries have experimented with guayule plantations, world rubber economics militated against success, and there are now no commercial plantations in existence; only in Mexico was there a continuum of development which has persisted to the present day, though interest has recently been rekindled in the USA and Israel. Mexican authorities are currently considering a programme of rubber production from an estimated 2·6 million tons of wild guayule, with a planned harvest of 300,000 tons per annum estimated to yield 30,000 tons of deresinated guayule rubber.

Guayule rubber produced before 1950 contained a high percentage of impurities (resin: 20–25%) and insoluble material (5–10%). Modern techniques for the industrial production of elastomers were not available at that time. Systems for handling elastomers in solution, and modern technology for the extraction of oils using solvents have only been developed since 1950. Such processes can produce guayule rubber with the necessary economic and technical specifications to compete with synthetic alternatives to natural rubber.

Mexico has abundant wild stands of guayule which makes immediate small-scale use possible and which will supply germ-plasm for future crops.

Whether or not Mexico or any other country can establish guayule as an economically viable crop, however, depends on many factors:

- Continuing price increases for petroleum derivatives and therefore for synthetic rubbers have lowered the competitiveness of synthetic elastomers. Guayule is an alternative, renewable, source of polyisoprene rubbers. It seems likely that in coming decades there will be markets for all the natural rubber that can be produced, whether *Hevea,* guayule, or other plants. There may be price protection policies by natural rubber-producing countries for their products; however, there is a continuing rise in world consumption of rubber, largely due to the needs of developing countries, and natural rubber is still preferred in applications that demand elasticity, resilience and tackiness, and low heat build-up as in radial tyres which are increasingly in demand. Also, *Hevea* can be cultivated only in a limited tropical zone, which makes it vulnerable to political, economic, or biological circumstances:
- The need to stabilize desert margins, to find crops adapted to desert environments, and to provide jobs and incomes for desert dwellers living where farming conventional crops is risky or impossible are justifications outside the realm of conventional economics for the cultivation of guayule.

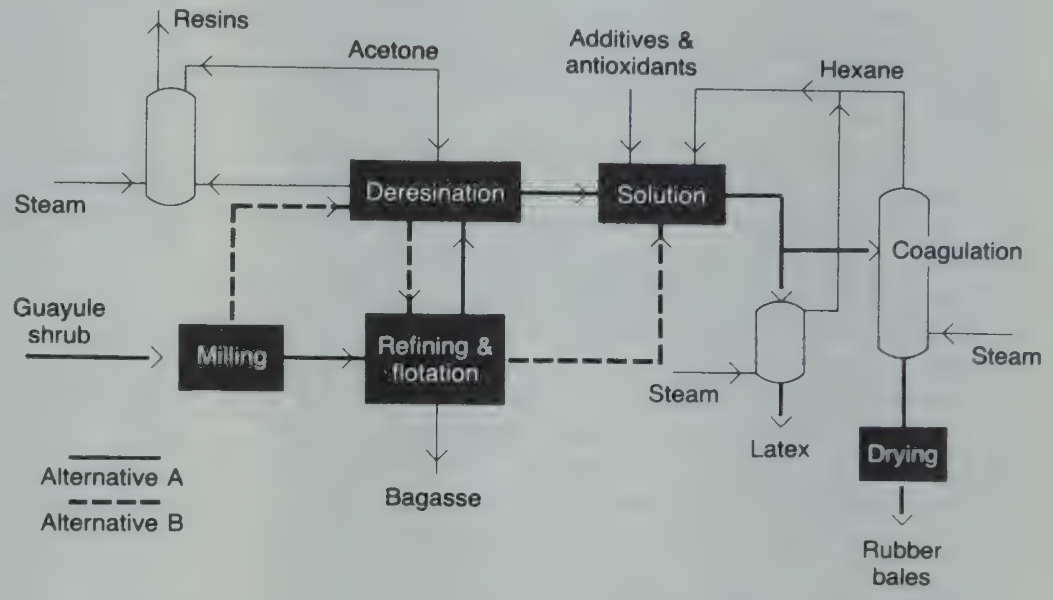

Figure 2 Guayule industrialization process alternatives, Centro de Investigacion en Quimicas Applicadas, Saltillo, Mexico (Campos-Lopez 1979).

A Mexican project to find an industrial process design reached pilot plant level of one ton per day in 1976 and allows the utilization of the different by-products: *bagasse,* resin (a complex mixture of terpenes, fatty acid triglycerides, etc.), and rubber (Figure 2). Having the rubber in solution gives a great deal of flexibility to the process, and allows production of different types of rubber; the characteristics of the final pilot plant product are similar to high quality *Hevea* rubbers. The equipment necessary for deresination is justified by the commercial value of the resins.

A recent analysis carried out by the Firestone Rubber Co. (Nivert *et al.* 1978) provides a very interesting view of what may be required for a commercial guayule rubber enterprise.

For this cost study a processing plant based on 50,000 planted acres of guayule was chosen. Assuming a four-year growing cycle, one fourth of the planted acreage, or 12,500 acres, would be harvested each year. Assuming that 10,000 lb of dry shrub was harvested per acre (1·5 lb/shrub, 7,000 shrubs/acre) then the plant would process 125 million lb of shrub annually. For the analysis, a rubber content of 20% was assumed, putting the plant's rubber capacity at 25 million lb per year. The plant was also assumed to operate on a year-round basis. The nurseries were to be irrigated but the field crop was to be produced by dryland farming methods.

Cost calculations relate to the year 1985 since it is believed that, under the most favourable research progress, a processing plant could not be built earlier than this date. Revenues are based on a projected price for rubber in 1985 of 56 cents/lb. The projection is well below the World Bank forecast of 78 cents/lb for this same year but a conservative approach was chosen deliberately.

The capital investment breakdown is as follows: process unit investment is $12·5 million, offsites and buildings add $9·7 million, contingency and inflation bring the total to $27·3 million.

A production cost summary (Table V) shows that the high raw materials cost is, in part, offset by the large by-product credit. The net cost with the base system is 43 cents/lb of guayule rubber produced, yielding 5·4% return on investment when the rubber value is set at 57 cents/lb.

For a 50 million lb/yr plant at a 20% rubber content a total expenditure of $68 million is required prior to start-up. This expenditure is offset by cash flow during production (cash flow = net profit + depreciation).

A pay-out period of slightly greater than six years after tax is determined indicates that the project would be reasonably profitable. The rubber content of guayule is quite critical to the viability of the operation and should be in excess of 20%, but it has been shown that rubber production in guayule also can be bio-induced by chemical treatment (Yokoyama *et al.* 1977); its value is also critical. Recovery of the major by-products (resins, wax, pulp) is essential as seen in the production cost estimates where credits amounted to 15·0 cents/lb of rubber. In this analysis costs of 21·1 cents/lb of rubber were estimated based on a number of assumptions (which must be confirmed) for nursery operations and payments to farmers for the crop. Affecting cost will be harvesting cycle, plant size, plant spacing, soil and plant care requirements, etc. Unlike *Hevea,* the production of guayule is suited to mechanization at all stages from planting through harvesting and processing. Therefore, being less labour intensive, (if somewhat more energy demanding) the production cost differential between guayule and *Hevea* should progressively improve in favour of guayule the farther in the future the economics are projected.

Processing costs will vary considerably with plant size and considerable development must be done to determine the most economical process. In the process chosen the extraction steps appear to be the most cost-intensive. Early development activity should concentrate in this area, but a cost comparison with the flotation process should also be made.

Table V
Production cost summary; to produce 25 million lb/yr rubber

Plant cost	$27·3 million	
Production costs	**$1000's/yr**	**¢/lb rubber**
Raw materials	5,300	21·1
Utilities	—	—
Labour and overheads	9,300	37·2
Gross cost	14,600	58·3
By-product credit	3,800	15·0
Net cost	10,800	43·3

Source: Nivert *et al.* (1978)

'Oil plants'

Euphorbia species

Test plantings have been made in California of *Euphorbia lathyris* (an annual about 4 feet high) and of *Euphorbia tirucalli* (a perennial 15–30 feet high taking 2–3 years to come to harvest). An experimental planting of *E. lathyris* at the South Coast Field Station of the University of California in Santa Ana has so far indicated a yield of 8 to 10 barrels per acre in the February to September growing season though a Japanese plastics company is reportedly obtaining 15 barrels per acre from a plantation of *E. tirucalli* on the island of Okinawa (Calvin 1979).

Cost estimates by various researchers have varied from $18 to $90–117 per barrel of oil. Calvin's projected price of about $40 per barrel for the finished product, based on 10 barrels/ac was, in 1978, roughly twice the price of crude oil. However, the price of crude oil has escalated rapidly since then, and the hydrocarbons from *Euphorbia* contain a high proportion of C_{15} compounds such as terpene trimers with a molecular weight of around 20,000, which can be made to yield products similar to those obtained from naphtha, one of the principal raw materials that the chemical industry derives from petroleum. At the 1978 price of $50 a barrel for naphtha, hydrocarbons from *Euphorbia* are already competitive, and there is no doubt that yields could be improved by breeding and selection of improved strains.

Immediately prior to World War II there were schemes for the commercial exploitation of *Euphorbia resinifera* in French Morocco – where a plantation of 125,000 ha yielded 3 tonnes of hydrocarbon/ha which produced 1,700 kg/ha of rubber (benzene extractables) and 2,750 kg/ha of gum resin (acetone extractables) – and in Ethiopia, where an Italian project to produce hydrocarbons from various species of *Euphorbia* in a refinery at Agordat failed to materialize, no doubt overtaken by events of the times.

Another candidate for development is *E. trigona,* a native of Puerto Rico and Brazil, which grows either as a bush or as a tree with a girth up to 10 in. and which can apparently be tapped for its latex in much the same way as is done for *Hevea.*

There are, throughout the world, some 8,000 species of *Euphorbia,* many of which may be suitable for the growth, extraction and processing of oil-like materials. Many are capable of growth under semi-arid conditions and do not therefore require land which is suitable for the production of food.

Copaifera spp.

A recent account in the American journal *Science* (Maugh 1979) describes how Calvin, on a visit to Brazil "observed a tree in the jungle that produces virtually pure diesel fuel". Copaiba, or copaiba balsam, has long been known to commerce and not just "to the natives of the forest". It is a natural oleoresin derived from various species of *Copaifera,* large leguminous trees found commonly in Brazil, Venezuela, Guiana and Colombia, and to a lesser extent in E Africa. The most important is said to be *C. langsdorfii* but this species is not included by Friese (1934) in his description of the economic characteristics of eight of the fifteen Brazilian species. Hill (1937) gives Maracaibo copaiba, from *C. officinalis* (Venezuela) and Pará copaiba from *C. langsdorfii* (Brazil) as the most important commercially and states that "so much oleoresin is secreted and stored in cavities that sometimes the pressure causes the trunk to burst open". Exudate from the Pará variety yields 65–80% oil which consists mainly of the sesquiterpenes β–caryophyllene and cadinene. It was used extensively in varnishes and in medicine; Calvin suggests that it could be used unadulterated to power a diesel engine, but its value might be greater as a chemical feedstock.

Croton spp.

Currently workers at the Federal University of Ceará in NE Brazil are carrying out a feasibility study on *C. sonderianus,* known locally as the Marmeleiro tree which, its protagonists claim, will produce oil with similar characteristics to those of diesel oil *plus* a crude oil similar to petroleum, ethanol from its cellulose and lignin which can be used as fuel. The plant is some three to four metres high, and regenerates quickly after pruning, producing new shoots almost two metres long in four or five months.

Yields are estimated at 15–45 tons of green material/ha per year of which 1% can be extracted as volatile oil; principal constituents are terpenes and sesquiterpenes, mainly pinene. A comparison of its properties with those of diesel oil are shown in Table VI. Of the other constituents, the crude oil has a calorific content of 9,000 Kcal/kg, some 150 litres of ethyl alcohol and 100 kg of protein per ton should be realizable and the lignin, which itself has a calorific value of 6,000 Kcal/kg, can be used directly as fuel or added, in suspension, to fuel oils.

The authors of the study (Parente 1980) have designed a model of an agro-industrial complex around a 60,000 ha unit of cultivation with an assumed productivity of 20 t/ha of green material per year.

It would be necessary to have an additional area of 24,000 hectares for the provision of fuel wood sufficient for the thermal needs of the conversion processes. Furthermore, there would need to be areas for industrial installations, commercial and social facilities, for subsistence farming and for forest reserves.

The complex would be made up of 20 industrial units, each one supported by 200 agricultural units and 60 forest units, both of 20 hectare size. The system would also contain a unit for the breakdown and refinement of crude oil. Each agricultural or forest unit would be worked by a farming family which would be responsible for cutting 300 tons per year of the oil tree or of wood, and for transporting this material to the appropriate industrial unit, which would produce and market their products (alcohol, lignin and proteins), furnishing the crude oil for the refinery which in its turn would produce and market diesel-type oils, and other raw materials for industry.

Table VI
Physical properties of diesel oil and the oil from Croton sonderianus

Physical properties	Diesel oil	Essential oil from *Croton*
SSU viscosity at 100°F	38	40·6
Flare point V.A. °F	185	140
Combustion point V.A. °F	200	160
Density	0·8285	0·8933
Calorific power Kcal/kg	10,800	10,200

Source: Parente 1980, unpublished

Such a complex would directly generate work for 5,600 families, 850 industrial workers, and a few hundred other administrative employees for the production units; the amount of indirect employment would be considerable.

Table VII shows estimated annual revenues and unit costs of the products; these costings are based on numerous assumptions which obviously need to be verified. But, as in the case of the guayule rubber cost analysis, they give some indication of where the capital and running costs lie.

It would be interesting to know whether this study group has examined the feasibility of reviving the industry which at one time centred around the small tree *Manihot glaziovii,* a native of the desert regions of Brazil, which was tapped for its exudate and produced a high-grade rubber known as Ceará rubber.

Algae

Botryococcus braunii is a green alga which grows widely and can produce hydrocarbons up to 75% of its dry weight, depending on growth conditions and the strain used.

The hydrocarbons range from C_{17} to C_{34} chain lengths and are produced as an extracellular product causing the algae with higher proportions of hydrocarbon to float. Once the algae have been removed from the water, the hydrocarbons are easily separated by solvent extraction or destructive distillation (which can produce fractions similar to diesel oil and kerosene). A detailed report from the Australian Department of Defence (Hillen & Warren

Table VII
Annual revenues and unit costs of an industrial unit of the Ceará model complex

Product	Price Cr$/unit*	Quantity Unit/yr	Value Cr$	Unit cost Cr$/unit
Alcohol	7·5/l.	9,000,000 l.	67,590,000	4·2
Lignin	350·0/ton	15,000 ton	5,250,000	196·6
Crude oil	3,000·0/ton	2,500 ton	7,500,000	1,686·0
Protein concentrate	4·0/kg	6,000 ton	24,000,000	2·2
Total revenue			104,340,000	

Source: Parente 1980, unpublished
* Cr$50 = $1

1976) draws together much of what is known about the organism.

B. braunii occurs widely in nature, from Australian brackish lakes (where the dried remains of the algae, known as Coorongite, were responsible for early oil rushes) to water butts in London. Similar materials found in other parts of the world are named according to their local origin (N'hangellite from Mozambique, Balkashite from Turkestan, etc.). The material appears to be black but is yellow in thin sections under transmitted light. Thin pieces are flexible, not unlike crude natural rubber or bitumen, for which it was frequently mistaken.

Productivity data are only available for laboratory flask culture under continuous illumination and for natural, and unpredictable, algal blooms, neither of which are much use for estimating the productivity of *B. braunii* in mass culture. The Australian report suggests that the following investigations merit early attention:

- Laboratory and field studies of the conditions necessary to maximize growth and oil-production rates:
- A pilot-plant study to determine whether intensive cultivation can produce *B. braunii* growth rates comparable to those reported for other algae:
- Development of appropriate cultivation, harvesting and processing techniques, and determination of the suitability of the resulting 'solar crude' as an alternative source of fuels and lubricants.

The unicellular green alga *Dunaliella bardawil* is being tested on a pilot scale in Israel for its ability to utilize solar energy to produce glycerol, an important organic compound for industrial use (Ben-Amotz 1977). *Dunaliella* grows and multiplies on a broad range of salt concentrations, from the low salinity of the ocean to the almost saturated salt solution of the Dead Sea, accumulating free glycerol to counterbalance the salt concentration of the growth medium. Under optimum conditions of cultivation and high salinity, 85% of its dry weight is glycerol. Investigations so far suggest that *Dunaliella* requires no more than sea water, carbon dioxide and sunlight which makes it an extremely promising biosynthetic feedstock for the conversion of solar energy to chemical energy in the form of glycerol. After processing, the alga may be used as animal feed, as it lacks the indigestible cell wall found in most algae and, in addition, the pigment β- carotene can be extracted in worthwhile amounts. Thus the three products glycerol, pigment and protein seem likely to make this recent pilot-scale venture economically viable but, as yet, no yield and cost data are available.

Vegetable Oils

Oils from sunflower, soya bean, palms, etc., can be used in diesel engines or can be mixed with diesel fuel in various proportions. There are some problems with contaminants in the oil that can affect the engine but there is renewed interest, e.g. in Brazil, the USA and S Africa, in using plant-derived oils and fuel extenders especially for 'on-farm' use; the suggestion has been made that planting 10% of a mechanized maize farm to sunflower would ensure complete fuel self-sufficiency for the farmer; net energy ratios appear to be very favourable.

The possibilities of using tropical oil-producing plants, such as oil palm, as a fuel resource deserve more attention because their possibilities for extraction and direct use offer advantages over sugar and starch crops-for-fuel which involve fermentation and distillation processes. Moreover, intercropping or agroforestry is ideally suited for palm plantations.

The question of whether oil crops should be used as a fuel or as food will, of course, have to be a local decision whether it is economically or politically based, a question which also encompasses other biomass-for-energy crops where there is direct food/fuel competition. It is a very important and contentious point at this time and one that cannot be easily resolved. Undoubtedly it would be best to use marginal lands and agricultural residues for fuel but local social and economic criteria may well be over-riding in the decision processes (Pimentel 1979, Brown 1980).

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From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

29/7/87

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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OFFICIAL NEWSLETTER OF THE UNITED NATIONS CONFERENCE
ON NEW AND RENEWABLE SOURCES OF ENERGY

Special Conference Issue

THE UNITED NATIONS UNIVERSITY

UNITED NATIONS CONFERENCE ON
NEW AND RENEWABLE SOURCES OF ENERGY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

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THE UNITED NATIONS UNIVERSITY
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EDITOR'S NOTE

SPECIAL CONFERENCE ISSUE

This issue of ASSET is devoted entirely to the United Nations Conference on New and Renewable Sources of Energy which will be convened at the Kenyatta Conference Centre in Nairobi, Kenya, from 10 to 21 August 1981. The space usually occupied by abstracts is devoted to discussions of the issues before the Conference.

The pace is set by the introduction of Mr. Soedjatmoko, Rector of the United Nations University. This is followed in the second section by reflections on the history of and prospects for the Conference from two viewpoints: that of a former member of the Conference Secretariat and that of a member of the mission to the United Nations from the Government of the country hosting the Conference.

The third section is devoted to the North-South issues related to new and renewable energy sources. The paper of Messrs. Strong and ul Haq is the chairmen's report of an expert group meeting convened by the North-South Round Table to discuss the potential for international co-operation on policies and options presented by the Conference. The paper of Mr. Schwartz is written from the perspective of a corporation involved in energy development in the industrialized world.

Section IV addresses some technical and economic issues before the Conference. The paper by Dr. Agarwal, and Messrs. Bartlem and Hoffmann considers the problem of technology transfer, while that of Dr. Daghestani addresses the problem of building national capacities to utilize renewable energy. The paper of Messrs. Malinowski and Kubitz provides an example of the use of new energy sources by a public utility in one of the most highly industrialized areas in the world. The paper of Prof. Sachs presents an overview of the triangular interactions between energy, food and ecodevelopment. The final section is devoted to case studies by Dr. Swaminathan and Prof. Goldemberg from two developing countries, India and Brazil with large commitments to the development of national renewable energy programmes and considers their experiences in overcoming barriers to implementing such programmes.

For assistance in the preparation of this special issue we wish to acknowledge the valuable contribution and tireless efforts of Mr. Thomas Hoffmann of the International Institute for Environment and Development.

POTENTIAL FOR ASSET

With two and half years publication experience behind us the United Nations Conference on New and Renewable Sources of Energy has provided the stimulus to pause and reflect on the present status and possibilities for the future development of ASSET.

PRESENT ACTIVITY

In January 1979 the United Nations University embarked on the establishment of an information network on new and renewable sources of energy for scientists and engineers in developing nations. This information dissemination network is based on the need to link scientists and engineers active in these fields so that they may benefit from data on the latest advancements in technology and the non-technological aspects of solar, bioconversion and wind energy technologies of importance to their work.

The basis of this network is the information dissemination service built around the publication, Abstracts of Selected Solar Energy Technology (ASSET). Published 10-12 times per year, ASSET contains abstracts of recent books, articles, reports, and conference papers concerning these energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries as space permits. In addition to the abstracts, each issue includes one complete reprinted paper of particular interest to recipients, excepting the last issue of each year which is devoted to a list of the members of the ASSET network. Issues contain abstracts of recent publications balanced with those from the extensive older literature which may be useful to ASSET members. Presently all abstracts are in English and, when available, in other languages for non-English language publications. The preparation and free distribution to scientists and engineers in developing countries of ASSET is co-ordinated through the United Nations University headquarters in Tokyo. Members of the network are expected to send to the Tokyo office copies of relevant books, articles, reports and conference papers which they prepare in order that the results of their work can be shared with fellow members. These documents are abstracted and published in future issues of ASSET as space permits. Membership in the ASSET network is made by request only. At the time of request, all network members are provided with a sample and given the opportunity to make recommendations based on their needs for improving the contents of ASSET and services offered through the network.

At present ASSET members wishing copies of the full documents abstracted in ASSET are requested, where possible, to contact the authors directly. To this end, whenever available, the first author's institution and address are indicated in the abstract. It is hoped that this direct contact will foster closer co-operation and collaboration among scientists and engineers working in similar environments throughout the developing world. In cases where circumstances do not permit such exchanges, ASSET network members may request copies of full documents from the UNU Tokyo headquarters.

ASSET is also available free of charge to government officials throughout the world. Although originally intended for specialists in developing countries, numerous requests have been received for ASSET from individuals and institutions in industrialized countries. For this reason ASSET has been made available in industrialized countries at the annual subscription rate of US$25 by sea mail and US$40 by airmail. The abstracts which appear in ASSET are arranged in the following categories: general solar energy, bioconversion energy, wind energy, energy storage, and socio-economic aspects. Annual indices are prepared at the end of each year covering authors as well as subjects.

As of July 1981 the total ASSET network membership was 878 from 97 developing nations. ASSET is also available in 24 industrialized countries, provided to 58 United Nations organizations including UNDP field offices and deposited in libraries in 38 countries throughout the world.

In addition to the material provided by ASSET network members, four information centres are participating in the network by providing information from their computer files and documents. These institutions are the:

Japan Information Center of Science and Technology, Japan;
Tata Energy Research Institute, India;
Technical Information Center (DOE), USA; and
Technology Application Center (NASA), University of New Mexico, USA.

Although ASSET contains between 60 and 80 abstracts per issue, material is available to produce a publication about five times this size.

From the October 1980 issue, ASSET has been published as the official newsletter of the UN Conference on New and Renewable Sources of Energy and contains a section called "UNCNRSE Conference News". This new section of 4 or 8 pages per issue covers recent events, short summaries of relevant reports, national focal points and the calendar of events. During the preparatory period for the Conference, 1,000 copies of ASSET and 7,000 copies of the Conference News section are provided to the Conference Secretariat. In time for the Conference 1,500 complete sets of all the issues of the Conference News section will be collated and provided to the Conference Secretariat. Those who serve as national focal points for the Conference (about 100) are also receiving ASSET.

POSSIBLE DEVELOPMENTS

On the basis of a variety of recommendations and in response to expressed expectations from many quarters, particularly from developing countries, several possibilities for expanding and developing ASSET have been identified:

1. Translation into other languages

Numerous requests for translation of complete issues of ASSET into Spanish and French have been received. For this reason the UN University is presently exploring the possibility of co-operating with an institute which will undertake the complete translation of all copies of ASSET into French for printing in Tokyo. Similar possibilities exist and will be explored for the publication of Spanish language and Arabic language versions at some time in the future. It may also be of interest to consider translation of ASSET even into regional languages of Africa, Asia and Latin America.

2. Increased size

In view of the material available which is of sufficient interest and quality to be abstracted in ASSET, it would be advantageous to increase ASSET to 3-5 times its present size. Arguments against such a move have been voiced by those who wish to refer to only a very limited amount of selected information. However, the present 20-page size can be easily digested by most scientists and engineers and the value of information which cannot at present be put in ASSET should warrant considerable expansion of the amount of material abstracted.

3. Expanded coverage

While ASSET now covers only the fields of solar energy, bioconversion energy and wind energy, other fields of renewable energy sources could also be covered quite easily. Of particular interest would be hydro-power, especially small-scale micro-hydropower, and possibly geothermal energy and draught animal power. In addition, a special section could be devoted to abstracts on policy and decision-making in the field of energy, particularly new and renewable sources of energy.

4. More selected articles

At present only one selected article appears per issue, but this could be expanded to 2 or 3 per issue quite easily.

5. Distribution of copies

A common request from members of the ASSET network is to receive the copy of a full paper abstracted in ASSET. Although at some cost, the UN University is able to provide the number of copies required at present to fulfil such requests. However, much more could be done in this area and the University headquarters could serve as a centre for distribution of documents for all members of the network upon request.

6. Wider information collection

The information collection process could be more systematic and more objectively balanced by appointing centres or individuals in each country to provide the ASSET office with information on a regular basis. Such sources would prove invaluable for future developments of the information network in their respective countries of responsibility.

7. Reports on national programmes and activities

Many nations have renewable energy activities that are of interest to other nations. Much duplication could be avoided and cross-fertilization fostered by periodic reports on the programmes and activities of countries particularly in the developing world. ASSET could easily include such reports on a regular basis.

8. Reports on UN activities, programme and projects

With many UN bodies and agencies involved in new and renewable sources of energy, there is need to devote a section of ASSET to regularly and systematically provide information on the details and results of these programmes, projects and meetings. This will be most useful in bringing those interested, inside and outside the UN system, up-to-date on UN activities and will provide valuable information for co-ordinating activities within the system.

9. Calendar of world-wide renewable energy meetings

Such a calendar would round out the information on meetings available on the newsletter and would provide information for planners of future meetings so that overlap could be avoided.

10. Supplements

Supplements could be prepared from time to time on topics of importance to ASSET readers. Of particular interest would be the establishment of a forum where important issues in the field of new and renewable sources of energy could be discussed. The first area which comes to mind is the question of policy and planning in developing countries in the field of energy. This could take the form of presentations by decision-makers and government leaders responsible for energy planning in developing countries. Similar areas which require an open discussion of issues include: the interlinks between the food and energy crises and their impact on development programmes and strategies; socio-cultural impacts of introducing new and renewable sources of energy; the infrastructural, manpower and other requirements for utilizing new and renewable sources of energy in developing countries; questions of competition for valuable resources by several sectors of the society in addition to energy, for example, food and industrial products. Special issues of ASSET could be devoted to reports or extensive summaries of the considerable and important literature written by or for the UNCNRSE, including selected reports prepared by consultants for the Technical Panels and Ad-Hoc Expert Groups, and the Synthesis Group report.

11. Monographs

Under the cover of ASSET, state-of-the-art and state-of-research reports of a technical nature could be published from time to time. Such material might be prepared by a single author or a collection of authors in the form of a conference by mail. Most of the topics covered in ASSET would lend themselves easily to such review papers in those fields where reports have not already been prepared. Some could deal with broad technical questions such as rural energy systems, energy balances and flows in energy generation processes, and manuals, as well as reports on field experience on project implementation. Promising developments, research of significance and maybe advances could be reviewed on an annual basis for the entire field covered by ASSET.

Most of above-mentioned development require substantial funds and manpower. If ASSET has proven to be an effective tool in the efforts of the United Nations University to break the isolation of scientists and engineers active in the solar, wind and bioconversion energy fields in developing countries, it may be worthwhile to provide it with the financial and human resources to allow it to develop some of the activities proposed above.

TABLE OF CONTENTS

I. INTRODUCTION 1

II. UN CONFERENCE ON NEW AND RENEWABLE SOURCES OF ENERGY

THE CONFERENCE: BACKGROUND AND PROSPECTS (C. Ian Jackson) 5

CONDITIONS FOR THE SUCCESS OF THE NAIROBI CONFERENCE (D.D.C. Don Nanjira) 18

III. NORTH-SOUTH ISSUES

RENEWABLE ENERGY: POLICY AND OPTIONS (Maurice Strong and Mahbub ul Haq) 21

ENERGY IN THE NORTH-SOUTH DIALOGUE: A PRIVATE SECTOR PERSPECTIVE (S. Schwartz) 28

IV. TECHNICAL AND ECONOMIC ISSUES

SOLAR ENERGY: TWILIGHT OR DAWN? (A. Agarwal, T. Bartlem and R.T. Hoffmann) 33

BUILDING NATIONAL CAPACITIES TO UTILIZE RENEWABLE ENERGY: SCIENCE AND TECHNOLOGY POLICY ISSUES (F. Daghestani) 37

LOOKING TOWARDS THE FUTURE, BUILDING ON THE PAST: DEVELOPING NEW ENERGY SOURCES (J.H. Malinowski and K.R. Kubitz) 40

ENERGY, FOOD, ECODEVELOPMENT (Ignacy Sachs) 45

V. OVERCOMING BARRIERS TO IMPLEMENTING NATIONAL RENEWABLE ENERGY PROGRAMMES

THE CASE OF INDIA (M.S. Swaminathan) 47

THE CASE OF BRAZIL (J. Goldemberg) 48

I. INTRODUCTION

UNCNRSE: FIRST STEP TOWARDS A BROADER VISION?

Soedjatmoko
Rector
The United Nations University

The energy crisis that we now face is not so much one of absolute shortage as one of rising prices, of the struggle for access to and control of energy sources, and of the negative ecological and social impacts resulting from people's response to higher energy costs.

Therefore, this crisis can only be examined and confronted realistically in the broadest political, economic and social terms - it can not be fragmented, with a limited and narrow focus on certain energy options. The United Nations Conference on New and Renewable Sources of Energy (UNCNRSE) can be of great importance, but only if it is viewed as a first step towards an integrated approach by the international community to tackling the global energy problem in its full dimensions. What is needed - and what this Conference can begin - is a broad-scale examination of the total spectrum of energy sources and problems.

The fourteen energy sources with which the UNCNRSE is concerned have little in common with each other. Most of them are now and probably always will be of marginal importance for most of the world's population. Therefore, programmes in support of these sources should not divert resources from the development of conventional energy supplies in the developing countries. New and renewable energy sources must be seen as contributions, not as solutions, and evaluated in concert with the many facets of the energy crisis. This examination must cover not only all the energy sources of global importance such as oil, gas, coal and nuclear energy, but also the great array of other factors - economic, political, social and human - that are such vital determinants of availability of energy and the capability of populations to consume it.

Energy issues can only be considered in the broader, longer-term context of global development and addressed accordingly. This should include elements like preferential access by energy-deficit poor countries to sources of energy supply guaranteed through international agreements, while rich energy-consuming countries commit themselves to a policy of energy conservation as a contribution to the solution of the crisis. Such measures to ensure the energy security of countries could involve contributions from the OPEC as well as the industrialized nations. Alternative regional arrangements could be established which would involve the sharing of energy resources of various types among the nations of the region. And while short-term solutions will have to be worked out as well, no developing country can avoid fundamental societal adjustments as a response to the end of the era of cheap energy, and to the realistic high cost of energy as a feature of the next two decades.

The basis of such a response will lie in efforts to diversify energy-supply sources and to maximize domestic energy production from oil, gas, coal, hydraulic and biomass resources and a vigorous programme of energy conservation.

In addition, the use of locally available and renewable energy sources should be actively encouraged. While serious consideration should be given to the potentialities of agriculture as an energy producer, assurances will have to be made that this will not exacerbate the problem of poverty, hunger and inequity. Efforts to cope with the pressures on the balance of payments and the need to mobilize capital for structural adjustments of production capacity away from oil will have to be continued as well.

While not trying to divide the world, it is easy to see that the urban and rural sectors of the Third World have different sorts of energy concerns. Urban-energy use in the developing countries is highly intensive, due to high population densities, and their problems are not unlike those of the industrialized countries. In the countryside, however, energy consumption drops off drastically. Fuelwood and agricultural wastes provide basic household energy to half of all those who live in the Third World. In 1980, 90 million of the rural poor could not even meet their minimum energy requirements, and another 488 million were depleting their fuelwood supply faster than they were replenishing it. The production of wood or substitutes must be put on a more sustainable basis.

Another exceedingly disquieting aspect of the energy picture in the poorest and most populous countries is its convergence with the food outlook. Rising fuel prices, boosting transportation and agricultural costs, will inevitably push food prices beyond the reach of hundreds of millions of already hungry people. Rising populations, despite the best efforts to reduce fertility rates, will continue to increase the demand for both food and energy. The developing countries will not be able to solve their food problem without solving their energy problem and, without a satisfactory solution to both, their economic growth will be severely constrained. The centrality of the food and energy nexus calls for a comprehensive policy approach. Only through a clear understanding of this food-energy pivot can the situation be turned around.

Thus, a full discussion of the energy problem inevitably forces us to look with new eyes at the problems of the poor. The energy available to the poor must be more than that required for mere sustenance, it must be enough to ensure development and growth and hold out the hope for a more humane and dignified existence. The present low-energy-use patterns of the poor must not be allowed to permanently entrap them at an unacceptable standard of living. Ways must be found to ensure access by the poor to adequate sources of energy.

A broad-scale examination of the many dimensions of the energy crisis and their complex interlinkages should also lead to a consideration of the resource endowments of countries, their future prospects for security in their access to energy supplies, the grouping of countries which share a similar situation with regard to energy within and between regions, and the potential for the sharing of resources, energy as well as others, among the countries of a region. Finally, it can be see how energy relates to the process of development and what the energy inputs required for development are. Such discussions are of great value because any systematic scrutiny of both energy costs and development strategies beyond the present methods of crisis management will have a profound impact on the lives of hundreds of millions of people throughout the world.

In this respect, the potential role of new and renewable energy sources should be viewed as more a developmental than a technical challenge. The primary issues facing developing countries are not how much and what kinds of new sources to adopt, but what kind of development should be pursued, what are the resulting energy needs, and how these can best be met. Energy choices must be seen as intimately linked to fundamental questions of social goals and values.

This leads to the recognition that of all the energy dimensions, the one which we must keep fixed most firmly in mind is the human dimension. The ultimate determination of which energy systems are acceptable and viable are not only going to come from the decision-makers and the experts. Neat and tidy packages describing the appropriate future energy systems will be to little avail unless they are socially and culturally acceptable to the people being asked to use them and make them part of their daily lives. The energy-use option must be seen as essentially a political and cultural choice, not a technological one. The role of the experts and the technologists is to ensure that as many proven and viable options as possible are available when the time for choice arrives.

A very important part of this effort will revolve around the question of technologies. It would seem evident that the stress should be on building technological capability in the developing countries themselves. This capability, moreover, will have to extend down to the village level, if it is to be economically and culturally viable, and thus will require an immense social learning process. In the short run, certainly, most developing countries will have to continue to import some technologies. They cannot afford to be left behind by the advances and breakthroughs in new energy technologies, nor will they have the resources, initially, to undertake research of their own in all these fields. This raises the issue of what the proper balance should be between importing technology and investing in national technical capability and what the criteria should be in evaluating the balance.

The question of transferring technology from industrialized to developing nations has its problems however. Ways must be found to assist the diffusion of innovations despite international legal and financial obstacles raised by patent conventions. The resolution of these problems will require higher levels and new types of international co-operation among research institutions of the North and the South on the basis of equality and mutual benefit. Resources must be found to finance similar co-operation among developing countries so that they can share the results of their own research.

The massive research effort required must ensure that the technologies employed are appropriate to the prevailing social, cultural, economic and environmental conditions. In the case of new and renewable sources of energy, the potential varies greatly from country to country and even from site to site within the same country. This may call for the establishment of regional and international research institutions similar to those that now exist in the agricultural field.

Biomass, for example, is one area where current research is clearly inadequate. The use of agricultural wastes and the growing of crops and trees for either direct energy use or conversion to liquid fuels is still at a very highly experimental stage. Even less is known about the potential impact of biomass-based fuels on food prices. There clearly appears to be a case for a series of international or regional biomass research centres, each of which could concentrate on a specific aspect of biomass, such as the development of fast-growing fuelwood trees, of energy plants on marginal lands, of liquid fuels, and of new biotechnology for the energy field. A consultative group for these centres could be formed to attempt to mobilize private and public funds to support and co-ordinate a research effort based on these centres and associated national institutions.

The fragmented nature of research on biomass and other new and renewable sources of energy also speaks to the need to improve the information flow in this area. Information is now dispersed across many fields of specialization. Instrumentalities need to be developed for gathering this information, sifting it, evaluating it and directing it to those who could make the best use of it. ASSET has demonstrated what a modest effort in this direction can do, but obviously a great deal more is needed. A viable information network on new and renewable sources of energy is one of the most feasible and yet useful outcomes the UNCNRSE can have.

As we have seen, energy technology is inextricably interlinked to food technology, environmental sustainability and population pressures. But it is essential to remember that the current energy dilemma is not a new phenomenon. In the past, most societies have experienced population pressures which have led to the intensification of food production. Such intensification has always led to environmental depletion which, whenever it was overcome, resulted in new systems of production or, failing that, in massive migration. By and large, each of these revolutions in production systems has been based on the adoption of a new fuel or energy source. Animal power, fuelwood, hydropower, coal, oil and gas have variously fueled many of these transitions, with the cycle being repeated many times in some societies.

However, for the first time in history, humankind will be moving not from an old to a new energy source but from dependence on systems supplied by energy from a single source to the use of a mixture of sources. This will call for entirely different strategies to handle systems that are much more complex, require more scientific understanding, and in which energy considerations are closely interlinked to many other economic, social, cultural, and political aspects of our lives.

It is particularly surprising to note that throughout the technical preparatory process for the Conference, and indeed in the NRSE field in general, almost no effort has been allocated to considering the technical implications of using a mix of energy sources in a single system. Problems of the interface between different sources, the integration of energy sources of different character and availability over time, energy storage, and source scheduling and interchangeability will have to be addressed as mixed energy supply systems are developed. This will entail new management techniques, new educational approaches, intensified training efforts and a generally more integrated level of understanding. These energy systems must also be seen as integrated into larger systems encompassing agricultural and food production, transportation and industry. Those countries that develop the concepts, expertise and infrastructure for handling such integrated systems stand a far better chance of handling the many inter-related problems which face them now and will confront them in the future.

II. THE UN CONFERENCE ON NEW AND RENEWABLE SOURCES OF ENERGY

THE CONFERENCE: BACKGROUND AND PROSPECTS

C. Ian Jackson*
Executive Director of Sigma Xi, the Scientific Research Society
New Haven, CT, USA

1. Introduction

The United Nations Conference on New and Renewable Sources of Energy (UNCNRSE) is primarily a political event. It will have strong scientific and technological elements but, like other UN conferences of recent years, it is essentially a meeting of representatives of national governments, concerned with matters of national policy and international co-operation. Such conferences are not convened easily; they require the general recognition of a current problem of pressing importance and global dimensions, which appears to need a collective response. In the case of the UNCNRSE, the problem is that of the energy situation facing all countries, and especially developing countries, at present and during the next two decades.

2. Energy and Development

Development involves the greater use of energy. The exceptions to this generalization are few, whether we are concerned with economic development or with social development. The industrial revolutions that took place in Western Europe and North America in the eighteenth and nineteenth centuries were based on the replacement of human or animal energy by water power and later by steam power based on coal. Many centuries earlier, the domestication of draught animals had enabled mankind to make an even greater leap forward in food production.

For the industrialized countries, the phase of massive growth in energy consumption may be past its peak, regardless of energy availability. These countries appear to be near the top of an S-shaped curve of energy demand *per capita*, with the prospect of new demands for energy in the future being largely balanced by greater efficiency in energy use. Since many of these industrialized countries are also close to achieving zero population growth, their future increases in energy demand are likely to be modest when compared to the last one hundred years, and particularly to the past twenty-five years. One forecast suggests a 30% growth in energy use in industrialized countries during the next two decades[1], but this may prove to be an over-estimate.

For developing countries, however, the situation is entirely different. Most developing countries are close to the base of the S-curve of *per capita* energy use; virtually all development opportunities and plans involve the greater use of energy, and the generally high rates of population growth also raise the level of demand anticipated in the future. The same source that forecast a 30% growth in energy demand in industrialized countries envisaged that energy use in developing countries will have to triple over the next two decades if reasonable levels of economic growth are to be achieved.[2] Whatever the objectives of national development policies - greater industrialization, improved agricultural methods, relieving men and women of onerous, time-consuming and debilitating tasks such as collecting water or fuelwood - energy is essential. Without access to increasing amounts of energy, there can be no development.

Access to energy has been one of the main constraints on individual and collective development throughout much of human history. But for a brief period of about twenty-five years after the end of World War II, energy ceased to be a major constraint in many countries because it was abundantly available at real costs far below those experienced before. The Executive Secretary of the United Nations Economic Commission for Europe (ECE) has remarked that the annual rate of world energy consumption trebled between 1950 and 1975, with more energy used in that period than mankind had burned in all the millenia up to that time. This was linked to, and a cause of,

> ...fantastic economic growth without parallel in human history. Because never before have we had a period of 25 years of uninterrupted economic growth at the high rate of 5 percent, or even more - never before.[3]

It was the industrialized countries, many of them members of ECE, that accounted for most of this rapid growth in energy use. In 1975 the industrialized countries, with a combined population of 900 millions, accounted for 82% of commercial energy use. The remaining 18% was shared among the 3,100 million people in developing countries although, in practice, most commercial energy use in developing countries is limited to a relatively small "modern sector" in each country.

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* Until April 1981, Dr. Jackson was a member of the Conference Secretariat at the United Nations headquarters, New York. Prior to that, he was a member of the Environment and Human Settlements Division, Economic Commission for Europe, in Geneva. Although the content of this article reflects his period as a member of the Conference Secretariat, the views expressed are the author's, and are not necessarily shared by the Secretariat, the United Nations, or any government.

Nevertheless, the benefits of the period of cheap energy in the post-war period were experienced by developing countries as well as by industrialized countries, and were a significant factor in the high rates of economic growth that many developing countries maintained during that period. Perhaps of equal importance was the implicit assumption made in development plans that further social and economic progress in developing countries would be based on still greater use of conventional commercial energy resources including: power for large and small industrial plants and for transportation, rural electrification schemes and diesel engines to pump village water supplies.

This assumption, and the expected pace of development, were forcibly called into question by the rapid and general rise in prices of all forms of commercial energy that took place after 1973. But in retrospect it is evident that the period of unlimited cheap energy could not last. The supplies of oil and gas on which it mainly depended are inherently non-renewable resources, and by the late 1960s the world appeared to have reached the stage where the rate of new discoveries was falling behind the rate of current production. The question of what would happen when supplies were depleted was one for producers and consumers alike, but it naturally was of special importance for producing countries, especially those that had few other sources of wealth. Conservation of resources - the recognition that oil may be more valuable tomorrow than it is today - and the maximization of returns from present production in order to establish an economic base for the future seemed logical responses in Alberta and the United Kingdom as well as in the Gulf and among OPEC member countries generally.

The end of the period of cheap oil should have been foreseen; it was in fact predicted by several authorities. What was not foreseen was the abruptness of the change, justifying the phrase "oil crisis", with oil prices rising in real terms by 500% (and taking prices for other forms of energy with them), in a period of economic down-turn for which the energy situation was itself a contributing cause. Another unexpected factor was the doubts that arose simultaneously about nuclear energy. To the extent that long-term planning for energy had been undertaken in many countries, there was in the 1960s a general assumption that nuclear energy would represent a growing proportion of commercial energy, replacing oil and other hydrocarbon fuels in electricity generation and hence extending the life of these hydrocarbon resources in more specialized uses. A few countries, notably France, still maintain a massive commitment to the development of nuclear electricity, but over the world as a whole a combination of political, financial, environmental and safety problems has caused nuclear power to assume a much more modest role in national energy planning than was the case a decade or so ago.

For industrialized countries, the change in energy prospects during the 1970s has been serious enough. Alternative fuels, notably coal, exist in large quantities, but the increased use of coal brings potential environmental problems (including acid rain and the longer-term possibility of significant climatic change), and the real cost of energy, in whatever form, is now far higher than it was at the beginning of the 1970s. There seems no prospect of a return to the period of cheap energy. Adjustment to this fact has not been easy: how many of the 16.4 millions of unemployed people in OECD countries[4] would be at work if the energy crisis had not occurred is impossible to determine, but the economic and social problems facing industrialized countries in the wake of the energy crisis are undeniably substantial.

For developing countries, however, particularly the low-income oil-importing countries, the problems have been much more severe and seem likely to remain so in the future. As the President of the World Bank has pointed out:

> The sharp rise in the cost of energy in recent years has underlined the urgent need to expand domestic energy production in developing countries that are dependent on imports. In 1980 they will spend about US$50 billion on importing oil. If their domestic energy production continued to grow no faster than in recent years (about 7% annually) their oil import bill (in constant 1980 US dollars) would rise by 1990 to US$110 billion, a level which would add greatly to the difficulty of financing an already large external deficit.[5]

In the World Bank's assessment, "The vast majority (92) of the developing countries depend in varying degrees on imported oil....Among [these] ... are 64 countries, including some of the poorest, that depend on imports for more than 75% of their commercial supplies."[6] These countries have a combined population of 395 millions; developing countries with a combined population of another 245 millions import between half and three-quarters of their commercial energy requirements.

These large external deficits, it needs to be recalled, are being incurred by developing countries to meet the costs of oil (and some other fuels) required for the modern sectors of their economies. While vital to national development, these modern sectors generally include only a small proportion of the total economy and a very small minority of the population. The vast majority of the population lacked the purchasing power to utilize commercial energy on anything but a negligible scale even during the quarter-century of "cheap" energy; what the rise in energy prices since 1973 has meant to these people is a sudden end to the tenability of the assumption that their future economic and social development would take the form of their increasing access to commercial energy based on fossil fuels. If development is to take place, then it seems inevitable that it must be based to a substantial degree on alternative forms of energy.

Meanwhile, a "second energy crisis" has developed, with much less fanfare than the oil crisis since it has had little effect on industrialized countries or on the modern sector of developing countries. But it is a crisis that directly affects perhaps half of humanity, the people who are dependent on fuelwood and on agricultural and animal wastes for fuel.

> Traditional renewable energy sources such as firewood, charcoal, crop residues and animal dung account for virtually all of the fuel used in many rural areas, and may account for about 20 to 25% of the total energy consumption in the developing world ... About 75% of the population of the developing countries uses traditional fuels, largely within households and primarily for cooking. Most of these people have access to firewood, but roughly 1,000 million people use agricultural and animal wastes to fuel their cooking fires.
>
> The rural energy crisis stems from the fact that the developing countries have been consuming their wood supplies far more rapidly than they are renewing them, with grave environmental, economic and human consequences....[7]

The environmental consequences include deforestation, soil erosion and siltation of water bodies. Lack of fuelwood has meant increased use of dung and other residues that might otherwise be valuable fertilizers: "It is estimated that the current use of dung for fuel 'costs' some 20 million tons of foregone food grain production annually."[8] The shortage also has severe social costs, which are the reverse of development:

> Villagers, mainly women and children, who could previously collect fuelwood in the immediate vicinity of their homes, now find in many cases that they must search for it half a day's walk, or more, away. For example, families in the upland areas of Nepal are spending the equivalent of 60-230 work days per year on fuelwood collection while in some parts of Tanzania 250-300 work days are required to meet family needs...[9]

The numbers affected by the crisis are already large but the problem is likely to intensify rapidly:

> The preliminary results of a study of fuelwood supply and needs indicate that about 100 million people in developing countries live in areas where there is already an acute shortage of firewood. About another 1,000 million are able to meet their minimum firewood requirements only by cutting in excess of sustainable supply. Under current trends of population growth, of fuelwood demands and of depletion of tree resources, over 2,300 million rural people in developing countries will need, within two decades, to be provided with large supplies of alternative fuels.[10]

For developing countries the two energy crises are evidently closely linked. Development should enable the population of these countries to reduce the amount of time spent on activities such as the collection of fuelwood, and release this time and energy for more productive activities. Yet the burden that developing countries carry at present in paying for the oil imports of their modern sectors is similar to the individual burden of those who search for fuelwood: the task becomes more difficult year by year and demands resources that could otherwise be allocated to development. The fuelwood crisis is, in fact, being intensified because many poor people find it impossible to continue their present small purchases of commercial fuel (e.g. kerosene) and are reverting to the use of "free" fuelwood or agricultural and animal wastes. For both crises, the need for alternative sources of energy is urgent and enormous.

3. The United Nations Conference Mechanism

From a substantive standpoint, the UNCNRSE will be concerned with a relatively novel subject, especially in a United Nations context, which has an urgency that could scarcely have been foreseen a decade ago. From another standpoint, however, the UNCNRSE is the latest in a series of such conferences on major world issues, organized within the framework of the United Nations, and taking place at the rate of about one per year since the Stockholm Conference on the Human Environment in 1972.

The Stockholm Conference, of course, was by no means the first major conference organized by the United Nations; many had preceded it, including a conference devoted to new forms and sources of energy that took place in Rome in 1961. But the Stockholm Conference in 1972 was a significant new departure, in that it and its successors have been political conferences in the best sense of that word: they have been attended by delegations representing national governments, whereas the earlier energy conference and others like it tended to be mainly scientific and "expert" in character. In terms of substantive content, the Stockholm Conference and its successors may appear to the outsider to be rather thin; in terms of the political commitment that they represent, however, they are undoubtedly a significant advance on many earlier United Nations conferences.

Apart from their basic political character, these conferences since 1972 have shared other important characteristics.

(a) They have dealt with issues of current concern to the world as a whole. Inevitably, some of the topics have been of greater concern to some countries and regions than to others, but the generality of the issues is undeniable: environment, population, water, human settlements, science and technology for development, the position of women, desertification and, in 1981, new and renewable sources of energy.

(b) At the time that each conference takes place, the issue with which it is concerned is one for which an appropriate United Nations mechanism or institution does not appear to exist. Sometimes, one of the main results of the conference is to establish such an institution (the United Nations Environment Programme (UNEP) was initiated by the Stockholm Conference), but often the topics are too vast and diverse for them to be encompassed by any single institution or mechanism.

(c) The objectives of each conference are also diverse, typically including the identification of desirable actions at the national and sub-national levels, as well as through co-operation among national governments on a regional or global basis. In addition, convening a conference is recognized as a means to increase public consciousness, and to assist the work of non-governmental agencies concerned with the issues.

(d) Lastly, but of considerable importance, each conference is a specific event. Much effort goes into its preparation; and permanent mechanisms or institutions such as UNEP may continue and expand the work afterwards. But there are significant differences (as well as some similarities) between the series of global conferences since that held in Stockholm and, for example, the Third United Nations Conference on the Law of the Sea (UNCLOS) and the United Nations Conference on Trade and Development (UNCTAD).

Preparations for the UNCNRSE are following a pattern that has evolved during similar work for earlier conferences, and that in several important respects was established in the preparations at Stockholm. Two years or more are generally allocated to the preparatory period; Resolution 33/148, by which the United Nations General Assembly (UNGA) determined that the conference should take place in 1981, was adopted in December 1978. A special secretariat was established in New York, led by a Secretary-General. The Conference Secretariat (approximately 20 professional posts) composed partly of people already within the United Nations secretariat, partly of those with appropriate experience or expertise who join on short-term contracts.

Although the Secretariat is the focus of preparations for the conference, its main activities other than those specified in relevant UNGA resolutions are determined primarily by a Preparatory Committee composed of governments. In the preparations for the Stockholm Conference, this consisted of 27 countries, selected according to usual UN practice regarding regional balance. Over the years, the size of the preparatory committees has tended to increase, and that for the UNCNRSE is open to participation by "all states", i.e. including states that are not members of the United Nations. The Conference itself will similarly be open to all states, representatives of certain national liberation movements and other organizations, other UN bodies and specialized agencies, and observes from intergovernmental and non-governmental organizations concerned with the issue (UNGA Resolution 35/204, para. 18). The Preparatory Committee for UNCNRSE held its first session (a brief meeting to organize its future work) in New York, 4-8 Feb. 1980, met for two weeks in Geneva in July 1980 and for three weeks in New York in March 1981. Its fourth session took place in New York from 8 to 26 June. Through its open membership, and through this sequence of meetings, increasing in frequency as the conference approaches, the Preparatory Committee has evolved into a mechanism for pre-negotiation of the Conference issues as well as a body that guides the preparatory process. In particular, its third and fourth sessions are dominated by discussions about the draft of the Programme of Action that will be considered and adopted at the Conference.

In conference preparations, however, the Preparatory Committee and the Secretariat are only the principal actors; much work goes on in other bodies of the United Nations system, in national governments and intergovernmental organizations, and in non-governmental organizations that see the Conference as an opportunity to develop their own related activities and, if possible, to influence the attitude of governments.

This non-governmental activity related to the objectives of the political conference also dates from the 1972 Stockholm Conference. Initially it was largely unexpected, and to some countries it may have been unwelcome. It was, for example, easy to see the non-governmental pressure groups concerned with the environment as identified with and drawing their main membership from a relatively small group of advanced industrial countries with market economies. Certainly it would be idle to pretend that non-governmental organizations are as broadly representative of the world as the 150 or more governments who participate in a conference. Over the years, however, the non-governmental role in such conferences has come to be taken for granted and even encouraged. It has been evident that such organizations are seldom a lobby for any particular country or group of countries, least of all the ones from which they draw their main membership. General ground rules have been evolved that separate the activities of the main conference from the NGO (non-governmental organization) forum that usually takes place simultaneously in the same city. It seems probable also that the governments which participate in a conference recognize the value of the forum in providing material about the subject of the conference that can be reported by news agencies, radio and television. In general, the formal conference provides little that is "news" in the conventional sense, and without the NGO activities the event might appear dull in the extreme.

The principal reason for this lies in the pre-negotiated character of much of the conference agenda. It is a common saying that "any well-prepared conference should be capable of being cancelled the night before it opens, with 90% of its objectives already achieved." The United Nations conferences since that held in Stockholm have aspired to that criterion. In particular, all the substantive preparations (i.e., in the case of the UNCNRSE, the review of the technical characteristics of different forms of new and renewable sources of energy, and of the opportunities and constraints affecting their use) will have been completed long before the delegates arrive at the Conference. What remains is of vital political importance - achievement of a consensus among governments on the conclusions and recommendations for future action - but this is a matter for quiet diplomacy rather than newspaper headlines. For those who have participated in or followed closely the long preparatory process leading up to a conference, the actual proceedings are understandable, fascinating and sometimes ultimately either exhilarating or dispiriting; for those whose perception of the conference is largely oblivious of this preparatory process, the proceedings may be incomprehensible and are certainly likely to seem on occasion tedious and irrelevant.

4. The Scope of UNCNRSE: defining "New and Renewable Sources of Energy"

UNGA Resolution 33/148, adopted on 20 December 1978, not merely initiated the preparatory process for the Conference; it also specified in considerable detail the subject matter and the priorities of the Conference. This was deliberate and desirable since "new and renewable sources of energy" could be interpreted in many ways.

Of the eleven substantive paragraphs in the Resolution, the first four are concerned with defining the scope of the Conference; the remainder deal with the preparatory process. In the first paragraph, the General Assembly simply

> "Decides to convene an international conference on new and renewable sources of energy in 1981 under the auspices of the United Nations;"

The second paragraph of the decision is more complex:

> "...the United Nations Conference on New and Renewable Sources of Energy should have the objective of elaborating measures for concerted action designed to promote the development and utilization of new and renewable sources of energy, with a view to contributing to meeting future over-all energy requirements, especially those of the developing countries, in particular in the context of efforts aimed at accelerating the development of the developing countries;"

Included in this rather complex UN syntax are two important features. First, the UNGA resolution takes for granted that new and renewable sources of energy are desirable. The primary purpose of the Conference is to promote their development and utilization, not (for example) to become preoccupied with evaluating their present or future role vis-à-vis other forms of energy, although such comparative evaluation is not excluded. Secondly, the emphasis is firmly placed on the energy needs of developing countries. Again, the role of these energy sources in industrialized countries is not excluded, but the priority is clear.

The third substantive paragraph

> "Defines the scope of the Conference as confined to the area of such new and renewable sources of energy as solar, geothermal and wind power, tidal power, wave power and thermal gradient of the sea, biomass conversion, fuel-wood, charcoal, peat, energy from draught animals, oil shale, tar sands and hydropower;"

This clear identification of fourteen sources has been of major importance in the preparatory process. The connoisseur of United Nations drafting will note the apparent contradiction between the use of the limiting verb "confined to", and the use in the same sentence of the phrase "such ... as" which clearly leaves the way open for consideration of other new and renewable sources. It seems probable that the limitation was designed to ensure that the conference agenda remained concerned with "new and renewables", and not expand to include conventional energy sources. In fact the preparatory process has remained limited to the fourteen sources specifically identified in the resolution; no other new or renewable energy source has emerged that demands inclusion, nor are the opportunities and constraints affecting such other sources likely to be significantly different from those examined in connection with the defined list.

It is evident, however, that the virtue of the list of sources lies in its specificity, not in its logic. As has been remarked many times during the preparations for the Conference, several of the sources are not new; several are not renewable, and one or two are neither new nor renewable. Included in this last category, for example, are oil shales; their utilization in France, the UK and other countries goes back almost 150 years, to a date even before the first oil well was drilled in Pennsylvania.

The list is therefore arbitrary rather than logical, but this has not meant that its usefulness is reduced. As noted already, one important feature of the paragraph is what it omits: coal, nuclear power, natural gas, and oil except that derived from shale, tar sands or biomass.

The fourth paragraph further limits the scope of the Conference by deciding that it should concentrate on (again with the inclusion of a slightly contradictory phrase, inter alia):

"(a) Analysis of the state of technology related to new and renewable sources of energy;

(b) Identification of the potential, particularly in the developing countries, for utilization of new and renewable sources of energy;

(c) Assessment of the economic viability of the use of new and renewable sources of energy in the light of the technologies now available and those being developed;

(d) Identification of measures for promoting, particularly in the developing countries, development of the technology required for exploration, development, exploitation and utilization of new and renewable sources of energy, taking into account the relevant results of the United Nations Conference on Science and Technology for Development;

(e) Identification of the measures necessary for the transfer to developing countries of the relevant technologies available, taking into account the results of negotiations relating to the transfer of technology in the United Nations Conference on Trade and Development, the United Nations Conference on Science and Technology for Development and elsewhere;

(f) Promotion of adequate information flows regarding all aspects of new and renewable sources of energy, especially to the developing countries, taking duly into account their special conditions and requirements;

(g) Question of financing the activities necessary for promoting the identification, development, exploitation and utilization of new and renewable sources of energy;"

It will be noticed that the first three of these sub-items are concerned with the characteristics of the energy sources themselves; the remaining sub-items deal with matters that are likely to require attention whatever source is being considered. As was no doubt intended, this distinction, and the specific sub-items, have been of considerable importance in guiding the preparatory process for the Conference.

5. Preparations for the Conference

In comparison with some of the other conferences since 1972, the preparatory process for the UNCNRSE has had a fairly clear pattern of organization. During 1980, twelve of the fourteen sources of energy were evaluated by experts, organized in eight technical panels.[11] A similar analysis of the other two sources (peat and draught animal power) was undertaken by two sets of consultants;[12] their reports were submitted early in 1981 at approximately the same time as the final reports from the technical panels. In a very brief period from mid-December 1980 to the end of January 1981, four more ad hoc groups of experts met to consider the common problems faced in promoting the use of all types of new and renewable sources of energy, most of which were indicated in the fourth paragraph of UNGA Resolution 33/148: information flows, finance, research and development and the transfer of technology, and education and training. In retrospect, a similar examination of environmental issues related to new and renewable energy sources might have been desirable, especially in view of the great diversity of sources under review. Two further ad hoc groups met within the same period to consider the implications for industry (both the supply of energy from new and renewable sources to industry, and the equipment and other requirements for increased use of these sources that needed to be met by industry) and the use of new and renewable sources of energy in agriculture and rural communities.[13]

The reports from these fourteen expert groups and two sets of consultants were analysed in the report of a Synthesis Group (whose composition included the chairmen of the expert groups) during a two-week meeting in New York in February 1981.[14] At this stage the substantive preparations (i.e. the analysis of the problems involved in promoting "the development and utilization of new and renewable sources of energy") was essentially completed. The emphasis shifted from substantive matters to political considerations: to the "elaboration of measures for concerted action" to meet the problems that had been identified and analysed. The Preparatory Committee of government representatives therefore resumed its central role in the preparatory process, during its third and fourth sessions, particularly in regard to the development of and preliminary negotiations concerning the draft Programme of Action for the Conference.

This summary of the main path of the preparatory process omits many other activities of considerable significance. For example, each of the five regional commissions of the United Nations has convened a special meeting on the conference theme;[15] at the meetings of the Commissions for Latin America (ECLA), Africa (ECA) and Asia and the Pacific (ESCAP) regional plans of action were adopted that are designed to fit within the framework of the global Programme of Action being developed for the UNCNRSE. Similarly the United Nations Educational, Scientific and Cultural Organization (UNESCO) undertook a survey of education and training needs for new and renewable sources of energy,[16] and the World Bank conducted a major policy review of its lending activities related to energy development in developing countries, especially renewable energy.[17] In addition to these and many other activities by bodies and agencies of the United Nations system (some of which would probably have been undertaken even if no conference had been arranged), other intergovernmental and non-governmental bodies have arranged events or undertaken studies on the theme of the Conference that, in different ways, have influenced the preparatory process.

6. The Substantive Message: the Prospects for New and Renewable Sources of Energy

The reports prepared by the technical panels, consultants and other experts on the various sources of new and renewable energy all have one general characteristic in common: there is a clear belief in practically all cases that these sources are either ready now for much greater utilization, or will be in the near future. Some of this enthusiasm is, of course, to be explained by the fact that the technical panels were composed mainly of experts in the particular energy sources, but the evidence and the judgements contained in the reports are generally convincing. There are one or two exceptions: the technical panel on ocean energy, for example, concluded that applications of wave energy were unlikely to proceed beyond the research stage during the next two decades. In the view of the panel, tidal energy was in a quite different category. The existing installations (notably the 240-MW station at La Rance, France have operated satisfactorily, and would be economic even if they had to be constructed at present prices. The main limiting factors for tidal power are some environmental concerns and the small number of suitable sites, probably no more than 40 throughout the world. In contrast to its pessimism on wave energy, the technical panel placed great faith in the contribution that could be made, beginning in the present decade, by systems designed to utilize vertical temperature gradients in the ocean as a source of power (mainly in tropical areas). This enthusiasm for ocean thermal energy conversion (OTEC) was particularly striking in view of the fact that the only operating system at present is a small research plant in Hawaii.

OTEC is exceptional: most of the mechanisms to utilize the different energy sources already exist even if, as with tidal power, they are to be found only in small numbers or, as with several forms of solar energy conversion, capital and operating costs are at present uncompetitive with alternative forms of energy. The technical panels on solar energy and biomass performed a particularly useful function by attempting to estimate when the various conversion systems would be ripe for major development. In several cases (e.g. sun-tracking thermal systems, photovoltaic cells, or use of vegetable oils for transportation), it may be the decade of the 1990s before large-scale developments are justified, but other systems (e.g. solar flat-plate collectors, passive solar systems, and ethanol and methanol from biomass) seem capable of much greater use in the present decade.

Many of the forms of energy considered already have a long history and widespread diffusion (e.g. wind pumps and hydropower systems), but the technical panels drew attention in several cases to novel techniques for using such long-established sources. Oil-shale extraction, for example, is usually thought of as a medium-scale activity producing a form of commercial energy, but the technical panel noted that Morocco has been making some encouraging experiments in simple and small-scale retorting of local shales, a system which might find wide use in the developing world in view of the very extensive distribution of oil shales.

Much of what the technical panels concluded can be found repeated in other recent surveys of alternative energy sources although the panels and consultants did survey the diverse sources in a generally comparable manner that is not easy to match elsewhere. But it is in regard to the more traditional energy sources, especially peat, fuelwood and draught animal power, that the reports provide a more unusual reminder that commercial energy is only one element in total energy use and often (especially in population terms) a relatively small part in developing countries. Improvements in traditional energy supplies and methods of utilization, though they may appear archaic or insignificant when compared to other possibilities, may have an enormous cumulative effect because of the vast number of people who use these sources. As the report on draught animal power pointed out

> Eighty-five to 90 per cent of Asia and Africa depend on manual and draught power, and the benefits of mechanization go to barely 10 per cent...Four hundred million draught animals in the developing countries, valued at $100 billion, make available 150 million hp, the replacement of which may need $250 billion. The modernization of draught animal power would amount to strengthening the instruments that would enable the small man to make a decent living, which he has been unable to do so far, as he has not been able to join the development stream fully in the last two decades.[18]
>
> ...In most situations there is no real competition or conflict between draught animal power and petroleum-based power, as has been demonstrated in China and some parts of India. Wisdom lies in using all sources, manual labour, draught

> animal power and petroleum-based power in the right mix, and not to consider one in place of the other. When more suitable and economic sources of energy are developed in the future, draught animal power could possibly be phased out. Meanwhile it is in the developing countries interest to upgrade their draught animal power systems.[18]

Similarly, the technical panel on fuelwood and charcoal found little need to emphasize the magnitude and severity of the fuelwood crisis facing a large part of the developing world. It did, however, indicate that urgent action was required in six main directions if the situation was to be improved significantly: intensifying the productivity of existing fuelwood resources; creating new resources; organizing distribution; improving conversion technologies (e.g. in the production of charcoal); improving the efficiency of wood-burning stoves; and exploring possibilities for substituting other energy sources for fuelwood in particularly uses and regions.

The fuelwood and charcoal panel emphasized that all the programmes that it proposed "are based on technologies and techniques which are available and known: the major constraints to massive programmes are institutional, economic and social."[19]

When the Synthesis Group came to review the work on the technical characteristics of the fourteen sources, as well as the conclusions of the ad hoc groups that had met specifically to consider the "institutional, economic and social constraints", it was in clear agreement with the fuelwood and charcoal panel. On the one hand,

> ...in economic and technological terms, general world-wide application of new and renewable energy technologies is now practicable. Several of these technologies are already feasible and call for rapid development, while others are in widespread use. Those technologies that have a modular character have inherent technical, social, economic and political advantages, and can be of great benefit to the rural populations of developing countries by virtue of their potential for delivering energy within reasonable lead times.[20]

The principal constraint, in the view of the Synthesis Group, was not the lack of trained people, of manufacturing capability, information, or even finance:

> The key issue in the role of energy in development is proper policy development and planning. Relatively few developed and developing countries have so far formulated and implemented proper national energy policies. In many cases energy plans, when they exist, are characterized by the following features:
>
> (a) plans and projects are often still based on the assumption of relatively cheap energy sources, and on established consumption patterns of oil and electricity;
>
> (b) estimates of future needs for energy are seldom based on an adequate analysis of the demand side of the energy equation, and rural energy demand is particularly liable to be neglected;
>
> (c) plans for energy and plans for other sectors of the economy are made independently of each other, thus resulting in a mismatch between the objectives of energy planning and the objectives of over-all social and economic development;
>
> (d) energy plans often neglect the present contribution and future potential of both new and traditional renewable sources of energy and frequently do not take account of the favourable foreign exchange implications that such new sources may have;
>
> (e) energy plans frequently do not fully take into account technological innovation and changing patterns of conservation.[21]

Although the technical panels had in several cases provided a useful (if sometimes controversial) comparative evaluation of the different conversion technologies available or being developed for each type of energy resource, it was naturally not possible for them to provide an over-all comparison of technologies across all fourteen sources of energy. This vital task was attempted by the Conference Secretariat in a paper prepared for the third session of the Preparatory Committee and, in modified form, included also in the report of the Synthesis Group.[22]

The Secretariat paper recognized that any attempt to compare different technologies and sources is bound to encounter enormous problems, such as those of site specificity and different technological maturity. How, for example, can one compare a hydropower proposal for an ideal physical site and an assured market with another hydropower scheme in a very different setting, let alone with alternative opportunities for wind, solar or marine energy? How can we compare a hydropower scheme, that can be built now with conventional technology, with an OTEC or solar power project that depends on specific technological improvements occurring in the next five years? The task of comparison is so difficult that some would argue it should not be attempted in general terms: better to evaluate particular energy needs and opportunities as they occur at specific places and times.

The Secretariat paper tried to minimize these and similar difficulties by focusing on the end uses of energy. It argued that energy is used in four main ways: as liquid fuels for transport; as centralized electrical power; as decentralized traction or shaft power; and in the form of heating and cooling of buildings and process heat for agriculture and industry. For each of these it is possible to define reference prices for contemporary conventional energy sources: the current world price of petroleum for liquid fuels and for heating and cooling; the energy costs of a coal-fired electricity generating station under typical conditions; and the cost of acquiring and operating a small diesel unit as a decentralized power source. The present or anticipated future costs of energy from the various technologies utilizing the fourteen sources can then be compared to the costs of these reference sources.

As noted already, there is plenty of room for disagreement. Is 7 cents per kilowatt-hour a reasonable figure for conventional generation of electricity at present (or 10 cents per kWh in 1980 dollars by the year 2000)? Are the costs assigned to different alternative energy sources now and in the future too optimistic or too high? The Preparatory Committee had some doubts: "... the basis for cost comparisons among different energy sources was ...criticized by some delegations, although it was recognized that substantial theoretical and data problems hindered a more comprehensive approach."[23]

Despite such reservations, few experts or government delegations have disputed the over-all conclusions of the analysis: that many sources of new and renewable energy are already economic and others are on the verge of large-scale adoption. The basic promotional purpose of the Conference is justifiable in terms of technology, economics, and utility.

It is also undoubtedly justifiable in terms of need. One of the characteristics of new and renewable sources of energy to which the Synthesis Group gave particular attention was the modularity of several forms and techniques of conversion. Unlike many conventional forms of energy, several alternative sources have limited economies of scale: they are as efficient in small-scale installations and applications as in larger ones. This is of particular importance in developing countries where, as noted already, there is often a wide gap between the amount of energy available to, and used by, the modern sector of the economy and the energy systems available to the vast majority of the population.

In many situations, indeed, it could be argued that the case for simple alternative energy systems (e.g. small wind pumps or hydraulic rams) would be very strong even without the recent massive rise in costs of conventional energy. The ability to utilize an energy source depends both on its availability and on purchasing power; the transmission lines of a rural electrification scheme bring little benefit to those who live beneath them if the latter cannot afford to purchase the energy. It has been suggested that a target of 100 watts per person (apart from traditional energy forms such as human and draught animal power and fuelwood) would represent a major achievement in many developing countries if this represented additional energy actually available to all the population. It might take the form of a pumped water supply for a village, some form of rural transportation, or a decentralized electricity scheme. In the words of the report of the Synthesis Group:

> Very small increases in the supply of electricity or fuels can bring substantial changes in the character and quality of local life, including increased productivity, development of local industry, provision of reliable water supplies, improved communication and education and improved health.[24]

Not merely are new and renewable sources of energy often economic and affordable in small, decentralized applications, many of the technologies are simple enough to be constructed, operated and maintained by local communities, without the complex technical and institutional infrastructure characteristic of electricity grids and other commercial energy systems. For example, there may be some disagreement about the potential of biomethanation (biogas) plants in different developing countries, but there is a general desire to initiate experiments to test their usefulness and acceptability. One organization that is encouraging such innovation is the World Scout Bureau which, in co-operation with the United Nations Children's Fund (UNICEF), has prepared a series of handbooks on the theme of 'Scouting, Development and Appropriate Technology'.[25] One of these is a guide to building a biogas plant, which is envisaged as a substitute for fuelwood in areas where the fuelwood crisis is severe.

7. Developing a Programme of Action for the UNCNRSE

As mentioned several times already, the UNCNRSE, like all its recent predecessors, will include in its agenda the consideration and adoption of a Programme of Action. Although there are many objectives in convening the Conference, most of these should have been achieved by the time it takes place. The preparatory process described above has already provided a greater understanding of the present and potential future role of new and renewable sources of energy, especially in developing countries. Many formal and informal contacts have been made among individuals, organizations and governments, and many initiatives and projects are under way that might not have happened without the stimulus of conference preparations.

The Programme of Action, however, is the single important objective that cannot be achieved in this way: it requires a process of negotiation and adoption (i.e. commitment) by governments that must take place at the Conference in Nairobi although much preparatory work can be done beforehand. The Programme will not, of course, include everything that will or should be done in the future: much will be undertaken by individual governments and bodies, with or without a programme of action. What the Programme of Action should contain in particular, however, are those elements and activities that are essential if the over-all objective of the Conference is to be achieved in the foreseeable future and that are not already provided for in World Bank or other programmes and plans. Expressed another way, it will be possible by the end of 1981 to look back at the Conference, including the preparatory process, and assess many of its achievements and failings. But the extent to which the Conference does succeed in "promoting the development and utilization of new and renewable sources of energy" can be judged properly only after a period of ten years or more. When we come to look back on the Conference from the vantage-point of 1991 (as UNEP and the environmental community are at present looking back on the 1972 Stockholm Conference) it will be the content of the action programme and the effectiveness with which it was implemented that will be of principal significance.

What will the Programme of Action for this conference contain? That question cannot be answered at present since even a draft Programme of Action, ready to be submitted to governments as a basis for further negotiation, is not yet available. All that can be attempted here is some identification of the principal characteristics that it is likely to have, on the assumption that it follows the general pattern established by earlier conferences, and a personal view of what a desirable programme of action might contain. The latter, it should be emphasized, is a personal view of the author: it may not be shared by the Secretariat, the Preparatory Committee, or anyone else.

One characteristic of a typical programme of action is that it is a combination of general principles and specific proposals. The combination is often not a happy blend; lofty aspirations sometimes sit uncomfortably with limited and relatively mundane specifics. This is, however, probably inevitable in a United Nations context. Since the Conference participants represent about 150 sovereign states, who are ultimately at liberty to ignore the Programme of Action if they wish, the Programme must attempt to encourage through general principles what it cannot guarantee in specific actions. If this sounds a weakness, the latter should not be over-emphasized. A substantial element in the Stockholm plan of action was a list of 27 basic environmental principles. Many of these have subsequently been incorporated in international conventions and other substantial and effective environmental actions.

A second characteristic of action plans and programmes (the terms have been used interchangeably in different conferences) is that they contain recommendations for action by both national governments and the international community. From a substantive viewpoint no other approach is sensible; the type of issue that is tackled at such conferences inevitably involves some actions that lie wholly within the powers of national governments, and others that require co-operation among governments. How much notice is taken of recommendations for national action will vary from one government to another, for both good and bad reasons. It has, however, often been noted that governments attending such conferences are not willing to assent to specific recommendations if they do not believe them to be relevant, desirable and feasible. Recommendations for international co-operation go, in formal terms, from the conference to the next session of the United Nations General Assembly for consideration and appropriate action. Here again, the governments attending the conference are, with few exceptions, those who will also receive the recommendations in the General Assembly and they will not normally agree to the inclusion of particular items in a programme of action if they are likely to be unwilling to endorse them subsequently in the General Assembly.

The key question that must be addressed in the recommendations for international action that go forward to the General Assembly is: what institutional mechanism will have the principal responsibility for the future work in this area within the United Nations framework? This preoccupation with institutions is perhaps unfortunate, but it also seems inevitable. The question also tends to have two main aspects: (a) Will the institution be "weak" or "strong"? (b) Will it be an existing body within the United Nations system, or is a new institution required?

A "strong" institutional mechanism is one that would have considerable power to initiate its own programme of activities, including substantial tasks identified in the over-all Programme of Action. Such an institution would probably be administered through a special committee or council of representatives of member states meeting regularly, and would have significant financial resources, coming either through existing financial mechanisms in the United Nations, or through the creation of some sort of special fund. The United Nations Environment Programme is an obvious example of a strong institutional mechanism established as a result of the Stockholm Conference.

A weaker mechanism might typically be one in which the primary function is that of liaison among governments and among United Nations bodies and agencies that undertook relative activities in accordance with their own priorities, under the direction of their own governing bodies and with their own resources. The primary objective of such a mechanism would be to achieve a more co-ordinated approach to the problems of (in this case) promoting the use of new and renewable sources of energy, so that the total of what was achieved by all the participants was more than the sum of its parts. Co-ordination, however, though undoubtedly desirable in principle, is notoriously difficult to achieve in practice, especially when the co-ordinating body has far fewer resources of manpower and finance than the agencies who are to be co-ordinated. Liaison and improved co-operation are therefore all that can realistically be achieved with such a structure. In addition to these functions, a "weaker" mechanism might also undertake useful but uncontroversial and relatively inexpensive tasks in encouraging, for example, information exchange, assisting research projects and training schemes.

So far as the second question - an existing body or a new institution - is concerned, this tends to answer itself once the previous question has been settled. In principle it is unlikely that any existing element in the United Nations system will be able to assume responsibility for the subject of conferences of the kind that have taken place since 1972. If such a body existed, then it would deal with the matter under its own mandate and according to the wishes of its own governing body; there would be no need for a special conference. Consequently, if a "strong" mechanism is decided on, this will normally involve the creation of a new institution with the necessary mandate, governing council of governmental representatives, and resources. If, however, a weaker mechanism is chosen, this can more easily be accommodated within existing UN structures with a modest amount of change.

Throughout the preparatory process for the UNCNRSE, there has been a strong indication from governments that they do not wish to establish a new institutional mechanism to deal with new and renewable sources of energy. To a considerable extent, this attitude probably reflects the generally difficult world economic circumstances. There is no point in establishing a new institutional mechanism unless it has reasonably adequate resources to carry out its mandate, and the early 1980s are not a period in which governments find it easy to make new financial resources available.

This general presumption that there will be no new and substantial institutional mechanism arising from the UNCNRSE naturally influences the whole approach to the development of a programme of action. If the latter is to be realistic, then what is proposed in the programme must be capable of being carried out within the resources and the institutional mechanisms that are likely to be available. Many would argue that a rather limited role for the United Nations is in any case desirable in principle, and should not be seen merely as the result of the unwillingness or inability of governments to support a stronger role. The preparatory process, it could be claimed, has demonstrated clearly that new and renewable sources of energy as so attractive that their increased use, especially in developing countries, will happen anyway, with gathering momentum. On this view the impetus given by the Conference may be its most important contribution, and extensive further action is unnecessary.

8. The Programme of Action: A Personal View

If, for the moment, we set this crucially important institutional question to one side, it is possible to approach the question of the desirable content of the UNCNRSE Programme of Action from a largely substantive basis. Given the fourteen sources of energy specified in UNGA Resolution 33/148, and taking account of the information and analysis that have emerged from the preparatory process up to the present, what might a desirable programme of action contain?

Five main elements can be identified, four of which are directly related to the characteristics of different sources of new and renewable energy. The first element, however, would be designed to address what was described, in the passage quoted earlier from the report of the Synthesis Group, as "the key issue in the role of energy in development": proper policy development and planning. Energy, in developing countries as well as in industrialized ones, has tended to mean commercial energy, mainly in centralized systems with elaborate and expensive infrastructures. Traditional forms of energy have been largely ignored, or have been treated as systems to be replaced rather than improved, and new and renewable sources of energy have also been neglected. Those responsible for energy planning and administration in governments have tended to have the same commercial energy background and training as those in the energy supply industries and utilities.

What is required, therefore, is not so much a bias in the future towards new and renewable sources of energy, but encouragement of and assistance towards national and regional energy reviews that eliminate the commercial energy biases of the past and that provide a broader analysis of resources, needs and technologies, with close attention to the role that energy should play in overall social and economic development. In many cases it seems likely that such a broader analysis would give more recognition to the present role of traditional energy systems; would give similar attention to decentralized and autonomous systems as to centralized systems; and would identify significant opportunities for the use of new and renewable energy sources.

A second main element in the Programme of Action might be specifically directed towards increasing the productivity of traditional energy sources, such as fuelwood and draught animal power. These are now, and will remain for a long time to come, the only or dominant energy sources available to half or more of the world's population. Because they have been ignored or treated as archaic and needing replacement in the past, it is paradoxically in regard to these sources that major new research efforts might yield immense benefits. But already many ways to improve the situation are known, relatively easy to accomplish, and are also relatively cheap when compared to the sums required by more sophisticated systems.

If a big research effort may be justifiable for traditional energy sources, it is unlikely to be required for the other sources of energy before the Conference. Or, more accurately, research on these forms of energy, from solar power to OTEC and tar sands, is not likely to need strong support of the kind that the United Nations can provide. In most cases the necessary research is already under way, with substantial sponsorship by national governments, public and private corporations, universities and other bodies. In the case of several of the sources of new and renewable energy, the technologies and the economics are well-known and ready to use. Wind pumps, mini-hydro schemes, biogas digesters and many other similar systems have already been proved in use over many years. In some cases they were an established part of the total energy supply, especially in industrialized countries, before the period of cheap and abundant oil after World War II made them appear old-fashioned, expensive and unnecessary. In the preparatory process for the Conference, such technologies have sometimes been described as being in a state of "arrested development". If the UNCNRSE is to bring really substantial results in the present decade, in the form of a massive increase in the use of new and renewable sources of energy in developing countries, it must be through a major effort to promote the use of these technologies that are simple and already available. This, then, might constitute the third main element of a Programme of Action.

A fourth, and probably much less significant, element might be related to those new and renewables that are also "mature", but that are more complex to develop, and that are oriented more towards centralized energy supply than the simple windpumps and other mainly decentralized systems described above. Large-scale hydro-power, tidal energy, oil shales and geothermal energy can all compete with "conventional" energy sources in many situations, and often have significant advantages in relation to external balances of payments, national generation of employment and manufacturing capability. Yet, apart from large-scale hydro-power schemes, there has been a tendency among financial institutions and other agencies to regard such sources as "unconventional" and therefore inherently less desirable than other forms of commercial energy. In the last five years the World Bank has made a series of changes in its lending policies for energy, which were previously concentrated on electricity supply (mainly from hydro and "conventional" sources) and coal. Similarly, it has been argued that the transnational corporations which have undertaken much of the search for and development of energy resources in developing countries have been preoccupied with the task of serving a world-wide market; schemes and resources with only local significance, or that required an unconventional approach, have tended to be passed over. The objective of this fourth element would therefore be to ensure that proposals for large-scale developments of new and renewable energy, especially in developing countries, are treated on a comparable basis with other energy projects.

The final group of new and renewable energy sources and technologies are those that are usually described (with greater or less degrees of optimism) as "emerging". Research or pilot plants and schemes may already exist, but it is expected to be several years, or one or two decades, before such systems are ready for large-scale adoption. As suggested already, it seems doubtful whether much encouragement of the research and development process by the United Nations would be a justifiable priority for available funds which are always likely to be small relative to the needs of the energy situation in developing countries. The objective of the fifth major element of a programme of action might instead be directed to ensuring that when these technologies are ready for adoption, they can readily be adapted to the particular needs of developing countries. This may require some applied research, efforts on transfer of technology, specialized training, work on the simplification of the hardware so that as much as possible of it can be manufactured in the developing countries that wish to use it.

In summary, therefore, the five main objectives of a programme of action that responds to the needs of developing countries and the opportunities provided by the fourteen sources of energy identified in UNGA Resolution 33/148 might be as follows:

I. Encourage and assist national governments to undertake energy policy reviews which give balanced treatment of traditional, conventional and new and renewable sources of energy in the context of over-all economic and social development.

II. Improve the productivity of traditional energy sources, such as fuelwood and draught animal power.

III. Initiate a major effort to promote the widespread adoption of new and renewable energy technologies that are already available, economic, simple and efficient.

IV. Ensure that large-scale projects utilizing new and renewable sources of energy are evaluated and treated on a comparable basis to conventional energy systems.

V. Encourage the development of emerging technologies along lines that will contribute to development objectives in developing countries.

Among these, the first is probably a sine qua non; the third is where the most significant results can be achieved during the next ten years or so. It would be relatively easy to identify specific measures, at both national and international levels, that would contribute to achieving these objectives.

What does, however, seem more difficult is to reconcile such a programme of action with a mechanism for implementation that is "weak" rather than "strong", and that is based more on co-operation among existing agencies and governments than on a leading role undertaken by a specific institution that made these objectives its own. As noted previously, it may happen, however, that much of the Programme can be achieved without such an institution, simply because the economic pressures are so great, and the opportunities are so attractive. Certainly the energy crisis of recent years is forcing many governments into energy policy reviews of a kind unlike anything attempted in the past. The World Bank is setting an example in regard to the fourth objective, and the expressed enthusiasm of the United Nations Industrial Development Organization (UNIDO) for mini-hydro and similar schemes is only one of several initiatives taken towards the third objective.

In any case, it must be emphasized that the objectives sketched above are essentially those of the author alone. Others would no doubt devise different objectives, or allocate priorities differently. Inevitably, however, there is likely to be a conflict between the energy needs of developing countries, the opportunities offered by new and renewable energy resources, and the willingness and ability of governments to act. Like the other conferences that have preceded it, the United Nations Conference on New and Renewable Sources of Energy will be an attempt to reconcile such conflict in an acceptable, feasible and effective compromise.

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CONDITIONS FOR THE SUCCESS OF THE NAIROBI CONFERENCE

D. D. C. Don Nanjira
First Secretary and Head of the Economic Division of
the Permanent Mission of the Republic of Kenya to the United Nations

1. The Setting

As a Kenyan who has been engrossed in the preparatory process from start to finish, I see the decision by the international community to hold the forthcoming United Nations Conference on New and Renewable Sources of Energy (UNCNRSE) in Nairobi as an honour and privilege, not only for Kenya but also for Africa as a whole. Obviously, the failure or success of the Conference will depend to a very large extent on the behaviour of Governments during the Conference itself and in particular their attitudes towards its purpose - its set goals and objectives.

In his address to the United Nations General Assembly on 7 October 1980, the Minister for Foreign Affairs of the Republic of Kenya, the Honourable Dr. Robert J. Ouko, M.P., said in part:

> "Energy is one of the most serious problems of this decade, and even of this century. The economic situation of the developing nations has been made particularly gloomy because of the energy crisis, and will almost certainly remain so for some time to come. Mr. President, Kenya is one of the developing countries most seriously affected by the energy crisis, and she was one of the first countries to see the urgent and imperative need to shift the dependence of countries from petroleum to a greater reliance on alternative new and renewable sources of energy. It is our hope that the United Nations Conference on New and Renewable Sources of Energy to be held in Nairobi in August 1981 will offer the world community a rare opportunity to find alternative solutions to our energy problems. My Government looks forward with enthusiasm to hosting that Conference, and we wish the Preparatory Committee for the Conference every success."

Thus, it was realized that the energy problem has become so critical: that it necessitates close international co-operation if effective and lasting solutions are to be attained; that the global problem of energy has intensified the dilemma of the developing countries, whose critical economic situation has deteriorated owing both to external negative forces and the rather unwise behaviour of all nations during the period of cheap oil; that there is an imperative need to educate public opinion and policy-makers of the significant role which alternative sources of energy can play in socio-economic development and to arouse public awareness of such energy sources and of the need to explore, exploit, and develop their potential; and that these options exist within the framework for an NIEO (New International Energy Order).

2. The Multi-Tier Dilemma of the Third World

The dilemma and frustrations of the developing nations stem from their structural, financial, human and material problems - all of which are serious impediments to the development of these countries. Much of this is due to the lack of infrastructures (transport, telecommunications and the necessary supplies of energy and water), the lack of adequate financing, and human impediments resulting from culture, tradition and collective egoism, as well as past and present capitalistic exploitation by external entities.

The principal material impediment to the development of the developing countries is the prohibitive cost of energy and its shortage of supply.

Perhaps nothing in a single generation has so deeply affected human relations and so profoundly changed the pattern, style and quality of life of the peoples of our "One World" than the events which resulted in the end of low prices of oil - the energy source that fuels much of the world's economic activity. This led to the consideration that fossil fuels could be depleted within a relatively short period of time and that nations should quickly shift their dependence from petroleum to alternative energy sources, in particular new and renewable ones, if the rapidly growing demand for energy by all countries is to be adequately met.

The dilemma is particularly serious for the non-oil-producing developing nations because the sharp increases in the price of oil have prompted sharp increases in the prices of industrial goods imported by this group of developing countries.

Thus, increased assistance to strengthen the capacities of the developing countries in the field of new and renewable sources of energy must be one of the fundamental goals of the Nairobi Conference. Assistance to the Third World by the industrialized countries and the International Community is essential for many reasons. Our world has shrunk owing to scientific and technological innovations and the world has become so small that no major event shapes a corner of the world without affecting another part of the same globe. Also, interdependence and mutuality of interests and vulnerability of nations require that international co-operation and assistance be extended to the disadvantaged countries. Finally, the "hot spots" of the world are located in the Third World, and one of the most effective ways of maintaining international peace and security is through the provision of assistance to the affected areas.

3. Kenya and the UNCNRSE: A Decade of Involvement

During period 1973-1981 it was demonstrated that, in the energy field, several options exist for a New International Economic Order, and that while continuing to follow the "hard path" of fossil fuels, a journey on a "soft path" of new and renewable sources of energy must be embarked upon. Kenya was an active participant in the formulation and creation of the idea of the UNCNRSE and has maintained an articulate position since then. As an oil-importing developing nation, she was and is still very much affected by the energy crisis and this situation has enhanced her interest and determination to find alternative ways of overcoming the energy crisis. This interest did not, however, spring full-blown from the events of 1973-74. We had in fact been associated with the concept of harnessing alternative energy sources much earlier than 1973.

But after 1973, it became clear that holding such a conference was necessary, and by 1977 Kenya had conclusively decided to support such a conference should it be proposed or to propose it if no other Member State of the United Nations took the initiative. We made our decision known to the international community both quietly in "diplomatic corridors" and openly through the Economic and Social Council (ECOSOC) and its subsidiary organs, which are directly concerned with energy matters, including the Committee on Natural Resources which, incidentally, later became the Preparatory Committee for the Nairobi Conference. In fact, it was in this very Committee that the idea of an energy conference was born in the year when the Paris Conference on International Economic Co-operation (CIEC) ended in failure on 3 June 1977 after 18 months of hard bargaining between the North and the South. It was also in the same Committee on Natural Resources that Kenya made it known expressis verbis in 1977 that time was indeed ripe for a conference on new and renewable sources of energy and that the sooner the international community decided on it, the better.

In 1978, I was a Member of the Kenya Delegation to the Second Committee of the General Assembly and we introduced what became General Assembly Resolution 33/148 adopted on 20 December 1978, and in which the UNGA inter alia decided to convene the UNCNRSE in 1981, to discuss fourteen such sources of energy and established eight Technical Panels of Experts and appointed a Secretary-General for the Conference. In 1979, I initiated a Resolution in the Group of "77" Developing Countries which was adopted by the Assembly on 18 December 1979, and in which the Assembly decided to hold the Conference in Nairobi in August 1981. In 1980, the General Assembly adopted Resolution 35/204 on 16 December 1980 in which it inter alia requested the Secretary-General of the Conference "to prepare a preliminary draft outline of a programme of action reflecting the consolidated conclusions and recommendations submitted by the Technical Panels, the Ad-hoc Groups of Experts, the Synthesis Group and organizations of the United Nations system." I need not dwell at further length on its history, purpose, and scope as well as the other preparatory work for the Conference. Suffice it to say that inputs into the draft programme of action have come from: national papers submitted by Governments; reports submitted by the Conference Secretariat; the six, Ad-hoc, Groups of Experts; the eight Technical Panels; the consultants on peat and draught animal power; the relevant organs, organizations and bodies of the United Nations system; the Preparatory Committee and the General Assembly among others. The main preoccupation of the Nairobi Conference should thus be the negotiation of a programme of action.

4. The "Irreducible Minimum" from the Conference

The questions that can be rightly raised in the context of the UNCNRSE are basically of a "what", "how" and "by whom" nature. For instance, what will be the fundamental issues before the Conference for discussion? What minimum decisions must the Conference adopt to qualify it for success and how and by whom should they be implemented after the Conference?

The negotiations in Nairobi should result in a Nairobi Programme of Action on new and renewable sources of energy which will provide for policy options for nations. It should elaborate measures for concerted action designed to promote the development and utilization of new and renewable sources of energy and agree on practical proposals for action on the fourteen selected sources of energy, which will entail short-, medium- and long-term policies and their implementation through mechanisms established at the global, international, interregional, regional, sub-regional and national levels. The Programme of Action should hence comprise technical aspects, bearing in mind the inputs of the various specialized agencies of the UN system and of the "scientific-technical" community, and political aspects which should require that, at the global level,a strongly and centrally placed intergovernmental body either be identified, designated, constituted or created (whichever will be the most appropriate) to deal specifically with new and renewable sources of energy and have the authority to require the UN system to provide inputs in this field in accordance with the guidelines established by the body. As the supreme organ of the General Assembly in the area of new and renewable sources of energy, the body should have the authority to establish its own specialized advisory organs and be serviced by a separate secretariat to deal solely with new and renewable sources of energy and be necessarily co-ordinated by the Director-General for Development and International Economic Co-operation. The Programme should further provide for a separate funding system and indicate clearly both the ways and means of raising funds for new and renewable sources of energy. The duties of the funding system, as indeed of the intergovernmental body, should also be spelt out. There should also be agreement on the critical issue of transfer of technology both in the North-South and South-South contexts, and a provision should be made for a review and appraisal mechanism, so that the Programme could be revised in accordance with changes and developments in the world energy situation as well as the results of future international conferences. Also the contributions of the Regional Commissions should be strengthened.

The nature of the intergovernmental body as the top policy-making organ of the General Assembly in the field of new and renewable sources of energy, with supreme authority, responsibilities and control in that field, should not be questioned. Thus, to negotiate successfully the afore-mentioned critical, political and technical issues in the Programme of Action, representation at the Conference should be at the highest possible level. Political will, commitment and determination should not be lacking. The policy measures to be adopted should be specific and action-oriented, and the ways and means of raising resources for new and renewable sources of energy should be elaborated in order to overcome existing constraints to the development and utilization of these sources of energy. The end of the Nairobi Conference should mark the beginning of a more integrated, concerted and accelerated course of action and the search for a lasting solution to the world's energy crisis. Priorities such as rural energy must be identified.

5. Political Will and Commitment: The Test of the Conference

The generation of political will to raise funds, to agree on adequate measures for the transfer of technology and the creation of new institutions, as necessary, specifically for new and renewable sources of energy, might prove to be the most valuable contribution of the Conference. The required technology exists to improve the situation resulting from the world's pressing problems, including the energy, food and population crises. What often leads to disastrous consequences in the world is the lack of readiness to honour political commitments which are sine qua non conditions and requirements for the attainment of equity and stability in the world. These general requirements include:

- finding solutions to the political problems which are the major obstacles to overcoming many critical problems;
- replacing confrontation and isolation in international behaviour and relations by partnership and interdependence;
- launching expanded investment programmes, whereby the private and public sectors, universities and the like, come together to work out solutions to pressing problems such as unemployment, energy, inflation, natural resources, money and finance, trade, and development;
- stimulating co-operative assistance to the poorer nations by the rich nations and the oil producers;
- co-operating internationally to increase food production in the developing areas of the world; and
- achieving a mechanism for general and non-discriminatory bargaining on world markets.

The UNCNRSE should be viewed, I believe, in the context of the foregoing requirements. The valuable documentation of the expert groups, the national papers and all the other reports submitted by the various organs, organizations and bodies of the United Nations system should be compiled, published and used in the future.

The Conference is no doubt a political gathering because it is a conference of Governments. Since, however, it will discuss critical technical and "specialized" issues within a very short period of time, political questions should not be the only questions which occupy the Conference.

I, therefore, hope that the delegations to the Conference concentrate on the fundamental issues before the Conference, including institutional mechanisms, financing, technology transfer and information flows for new and renewable sources of energy, so that the UNCNRSE will be a success.

III. NORTH-SOUTH ISSUES

RENEWABLE ENERGY: POLICIES AND OPTIONS

Maurice Strong and Mahbub ul Haq*

This is the Chairmen's report of an Expert Group meeting organized under the auspices of the North South Roundtable in preparation for the UN Conference on New and Renewable Sources of Energy (UNCNRSE) and convened at the request of the Secretary-General of UNCNRSE in Rome on 29 - 31 May 1981. The Group consisted of 32 leading thinkers and experts in energy and development fields who met in their personal capacities to debate candidly on all issues relevant to the subject. The authors caution that while this report draws upon these discussions and distils some of the major conclusions as perceived by them, they assume full responsibilities if they have not been able to do justice to the full range of views expressed at the meeting. To all those who contributed to this rich debate, they express their grateful thanks.

1. Nairobi Conference in Perspective

The UN Conference on New and Renewable Sources of Energy takes place as the world enters a period of historic transition in energy patterns. Although conventional fuels will continue to dominate the energy scene for the foreseeable future, the end of the era of inexpensive and plentiful oil is forcing profound structural adjustments in all societies. The energy future will be characterized by higher real prices, greater efficiency of energy use, a greater diversity of sources, and, for those making energy policies, greater complexity in decision making. In this challenging process of change, new and renewable sources can make significant contributions over time and under certain conditions but they provide no panacea.

The nature of the transition will differ among countries according to their levels of development and resource endowments. In developing countries, industrialization and urbanization necessitate further rises in consumption of oil and gas despite the higher prices of these fuels and the gradual introduction of alternatives. The industrialized countries, in contrast, face a transition away from excessive and often wasteful reliance on petroleum. Foreseeable global oil-production levels will not permit both rich and poor to continue pushing up oil use: that the poor deserve priority access to limited oil supplies is self-evident. Desperately in need of more energy, today's developing countries confront tremendous disadvantages compared to those countries which made the transition to industrial economies in the era of cheap oil.

The restricted scope of the UN Conference, a product of unfortunate political constraints, is not logical. The energy problem cannot be fragmented; neither analyses of technologies and their role in development, nor any new financial institutions designed to support energy investments should isolate new and renewable sources from the totality of energy sources.

Thus, programmes for new and renewable sources of energy should not divert resources from actions to promote development of other essential forms of energy in developing countries. In particular, measures to accelerate exploration for and production of oil, gas, and coal remain a top priority in many countries where the potential exists but has been inadequately explored.

Any new technical and financial aid activities launched by the Conference should be designed primarily to support appropriate progress in the developing countries. However, it should be stressed that, from a global perspective, the increased use of renewable energy sources may be even more critical in the richer countries. Further progress with oil conservation and substitution of alternative energy sources in the industrialized world will, by reducing pressures on the world oil market, ease the acute transitional problems of the poorer countries. As a group, the developing countries, which contain three-fourths of the world's people, account for just one-sixth of the world's oil consumption. Marginal changes in the oil demands of the rich can have major implications for the energy prospects of the poor.

Energy sources, renewable or otherwise, are not ends in themselves; they are part of the solution to a more basic problem: how to harness resources on behalf of human goals. The greater use of new and renewable energy should be viewed as a potential instrument for social and economic progress, rather than simply as a means of supplying particular magnitudes of energy. Thus, for example, the building of technological capabilities in developing countries should be stressed rather than the simple transfer of hardware. Worldwide, the top social priority must be the elimination of the absolute, degrading poverty in which some 800 million people now find themselves locked. A special focus on meeting the basic energy needs of the poorest countries and the poor within countries, helping to give them the power to improve their livelihoods, is essential. With energy, as with economics, the benefits of generalized policies and investments often fail to trickle down to those at the bottom.

The present maldistribution of energy consumption in the world is, in the end, a reflection of the maldistribution of income and wealth. Energy issues are inextricably intertwined with the full range of economic and political items on the agenda in discussions of the New International Economic Order. Energy choices are linked to fundamental questions of social goals and values; they should reflect the search for new and more equitable development paths both within and among countries.

The Nairobi Conference will, we hope, help to clarify the proper roles of new and renewable sources within these broader energy and development contexts. With the larger picture properly drawn, the Conference can then initiate practical action that will hasten the development and use of new and renewable sources of energy. The Conference proposals must have a sound technical underpinning and will involve many largely technical measures - but the Conference is a political meeting about how to organize people and institutions on behalf of political goals.

All institutional and financial arrangements emerging from this Conference should be viewed as merely a first step towards more comprehensive programmes in the energy field. We hope that this first step will eventually lead to a United Nations conference on energy as a whole.

2. New and Renewable Energy Sources and Development

The potential role of new and renewable energy sources is more a developmental than a technical challenge. The primary issues facing developing countries are not merely how much and what kinds of new energy sources to develop, but rather what kind of development to pursue, what the resulting energy needs are, and how these can best be met. The analytical task is made more difficult because the uncertainties of the energy transition overlay the always complex problems of development policy.

While generalization is dangerous, for most developing countries the energy-development transition would embody the following characteristics: the increased development of indigenous sources of conventional energy, together with increased efficiency of their use; the introduction and spreading use of new and renewable sources; a search for indigenous alternatives to present imitative patterns of production, consumption and technology; and an effort to relate energy strategies to the basic needs of the people. The actual contribution of new and renewable energy sources will vary considerably among countries, depending, among other things, on their endowments both of conventional and potential new and renewable energy sources.

The scope of the UN Conference encompasses some long-used technologies as well as those on the scientific frontiers. The significance of traditional fuels such as fuelwood, crop residues, dung, and draft animal power has historically declined as countries develop. Yet still today these fuels - which, when properly managed, are renewable - remain far more important to human welfare than has generally been reflected in development budgets. Close to half of humanity depends on traditional fuels for cooking, and many small industries rely on wood or charcoal.

The present pattern of fuelwood exploitation is, in many areas, unsustainable. One billion people depend on wood in areas where it is being cut more rapidly than it is regrowing. Some 100 million people already face acute shortages of fuelwood, with severe economic, social and ecological consequences. As societies modernize, the proportion of developing-country energy derived from direct use of fuelwood and charcoal will continue to decline. But for large numbers of people, wood will remain the basic household fuel even as other energy sources enter into their economic lives. Investments to meet this need are essential.

In terms of the gross level of energy that can be provided, hydropower looms largest among new and renewable sources over the years ahead. Today, large-scale hydropower already provides more than 40% of the electricity used in developing countries. With rising energy prices, the exploitation of an increasing number of hydro sites (large- and small-scale) has become feasible. Roughly half of the world's theoretical hydro potential lies in developing countries, only 10% of which has been developed.

Because of the major ecological, social and engineering problems they pose, and the often huge amounts of capital involved, the construction of large hydro facilities requires long lead times. Also, some otherwise attractive sites lack proximity to electricity markets large enough to justify the expenditure, although this suggests the opportunity for combining industrial with energy development. Several large rivers cross international boundaries and political factors have prevented the exploitation of their massive potential. According to World Bank estimates, construction of hydro capacity in developing countries at 1.5 to 3.5 times the present rate would be economically justified. The technology of hydropower is well known; the true bottlenecks are scarce capital and lack of political will.

Biomass technologies, including both conver-

UNCNRSE
CONFERENCE NEWS 9

SECRETARY-GENERAL IGLESIAS OUTLINES UNCNRSE TARGETS

I would like to share with you the basic ideas that I have tried to develop and that I have learned in the preparation of this Conference. I am convinced that in any human activity it is extremely important to have clear concepts and ideas to support any desired action. Thus, from the Conference Secretariat side, I would like to convey to you some of the basic concepts, aims and purposes that we are trying to build into this Conference as a foundation for its actions. This Conference, which was initiated in 1978 by the United Nations General Assembly, was the very first concrete response of the United Nations to the so-called "energy crisis". (Another response was to introduce the energy issue into the package of the North-South dialogue, where it is still being discussed.) The General Assembly selected fourteen sources of energy including: very important traditional sources like fuelwood, draught animal power and charcoal; relatively traditional sources such as wind and hydro power; newer sources such as solar, biomass, and geothermal; and others like peat and oil shale.

The Conference was born in 1978 under a series of constraints, the first being a political one. The political climate in the world at the time with regard to energy was rather unenlightened and did not permit much discussion for various reasons. This element heavily influenced in a somewhat irrational way the selection of the energy sources to be included. There are certain things which cannot easily be explained, for instance why coal was excluded. This was very much the result of the political atmosphere prevailing at that time. The second constraint was basically the great heterogeneity of the sources: some of them are very important today while others will be important in the future; some of them are technologically very advanced and others are still in the process of development; some of them are very relevant for developing countries while others are more relevant to the industrialized countries. The third constraint was the fact that it was not very clearly defined by the General Assembly whether this was to be an energy conference or a development conference.

Now, after two years of preparation, I think we are in a better position. In the first place, the political environment is changing and an active process of demystification has been taking place, particularly surrounding oil. The need for increasing the price of oil and the need for conservation have been realized. The blaming attitude towards OPEC is changing and there is a more constructive and realistic approach to defining the real nature of the issues surrounding energy. I would say that it is now easier to speak about energy in such a political forum as the United Nations; in 1978 it was not so easy. Also, the whole question of heterogeneity has become a little bit clearer to all of us after the presentations by the eight groups of experts who delt with the specific sources of energy. Some sort of a global approach to the whole package has evolved. In that respect, the Report of the Synthesis Group is very good and represents a certain commonality of approaches and conclusions. A diverse group of technical experts succeeded, to some extent, to put together a paper whose major virture is not so much the technical ingredients, which could perhaps be improved upon, but that it is truly a collective paper. Finally, the question as to whether this Conference is to emphasize development or energy is also a little bit clearer. It is evolving as an energy conference with a strong development linkage. In that respect, there has been in the last four or five months an active process of conceptualization. I am very pleased to tell you that many governments are agreeing on a series of principles (included in the first chapter of the Draft Programme of Action), and this is a very important component of the Conference. We must look at this Conference as only the beginning of the process of discussing energy within the United Nations and in order to do this properly it is extremely important that basic concepts be clear.

The purpose of the Conference is threefold: (1) to create an awareness of the need for an energy transition among the general public, at all political levels, and the policy makers of the world; (2) to place these new energy sources and our experiences in proper and realistic perspective within that transition; and (3) to identify areas for action within the international community. This is the Conference and, again, it is no more and no less than that.

Awareness of the Energy Transition

Everyone agrees that in the decades ahead an energy transition is inevitable and that the world must move away from the extensive and dominant use of oil into a new sort of energy mix in which oil will continue to play an important, but diminishing, role. This Conference is based on what the experts are telling us: such a transition is viable and possible. The world has no energy shortage. Energy in many forms is available, waiting for the proper technological sophistication and economic structures to release it for man's use. The difficulty lies in the transition. The transition is extremely complex economically, even in the short-run (the balance of payments crisis is one of the elements) for some countries. It is complex in the sense that the transition will require an enormous amount of capital and investment

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- a tremendous challenge particularly to the developing countries. It is also complex in the sense that the world is moving from a period of cheap to more expensive energy. This, itself, is a new situation and challenge that must be tackled simultaneously with the other above-mentioned elements.

We also believe that this transition is dynamic and that the world is in a process of rapid technological change, making it very difficult to imagine circumstances beyond a certain span of time. In essence, the transition appears to be a dynamic relation between resources, technologies, and investments. What is good or bad today might not be good or bad within ten years and vice-versa. This transition is taking place; we are not inventing it. The question is how to manage it, and how to manage it properly in an equitable, socially acceptable and economically viable way.

For the purpose of elaborating on the energy transition it is helpful to divide the world into two sectors: one is the "modern" sector which is composed of the industrialized countries and the modern centres of the developing countries; and the other is composed of the so-called traditional societies, which are basically the rural areas of the Third World. For the modern sector, conservation and efforts to increase efficiency in the use of energy are the most immediate items in the transition. A certain role will be played in the coming years by the new sources of energy, but it will not be a highly important or dominant role for a while. For the so-called traditional societies, there is an immediate need to develop, explore or provide access to more conventional energy. This is an important element which this Conference should make explicit and clear from the very beginning. It is not the intention of this Conference to divide the countries of the world into two parts: those consuming conventional sources, and those consuming soft sources of energy. One of the most important elements of the transition is to strengthen the capability of the developing countries to explore and find as much oil and gas as they may have and at the same time to provide elements to develop the so-called new sources of energy. Again, conservation is an important part of the transition for all sectors. There are many areas for conservation in the traditional sector, fuelwood being a very important example. We also foresee a very active role for the new and renewable sources of energy in the rural sector in the coming years.

Now, this is very much the way we are trying to envisage the so-called transition and the kind of ideas that the Conference should convey to the world in this very important first target area.

Place of the New Sources of Energy In the Transition

The second target is to try to determine the role these new energy sources should play in the overall energy field. I have been strongly indicating the need to neither overemphasize nor to understate the importance of new sources of energy in the future. Therefore, I consider the following statement to be of utmost importance and am very pleased to know that the Governments involved have agreed to include it in their conceptual and philosophical foundation of the Conference. This is a realistic philosophy which we are trying to focus upon:

> "The development and utilization of new and renewable sources of energy must be viewed in the context of the overall energy transition. New and renewable sources of energy can make a significant contribution, but their goal and potential should not be overstated."

I think this is one of the first times that a conference has very honestly started by saying that it doesn't want to oversell itself. In the foreseeable future, hydrocarbon products will continue to play the dominant role in meeting global energy demands. While the short-term potential of new and renewable sources of energy is limited in a global sense, the longer-term potential must be considered as very dynamic and important as fossil-fuel resources decline and new technologies mature. This is a very clear statement of our Programme of Action.

I would now like to emphasize two or three other elements which will be important in the future.

First, the world cannot and should not see the role of these alternative energy sources outside of the global concept of development. It would be a tremendously misleading policy to divert attention from the real and most essential element - development. Integral development has been the philosophy of the United Nations for years. Alternative sources of energy are only tools for achieving that concept.

Second, there is always a risk in taking a sectorial view of energy, and such a risk exists for this Conference. Energy must be thought of as an overall package; there is no such thing as a partial approach to energy. In the case of this Conference, we are being very cautious to look to these sources as part of an overall energy approach.

Third, nobody should look at this Conference as an instrument or a way to solve the immediate short-term problems of developing countries, particularly the balance of payments or investment. This is not the role of the Conference. This is the role of the North-South dialogue and involves a political approach to the immediate issues. It should be placed together with food and development problems. This Conference will not solve the problems of developing countries in the immediate future.

What is, therefore, the role of these sources of energy? Without becoming trapped by percentages, we note that some experts have shown that the energy package being considered at this Conference represents around 15 to 20% of the overall world energy supply. Others will argue against this figure, but I think it is more or less accurate. Some believe that at the beginning of the next century this package might represent 20 to 25%. Again, there is a big disagreement on this matter. Where there is no disagreement is that these sources represent 50% of the energy supplies in developing countries today. No matter what relevance renewable energy might be for the world as a whole, when you refer to developing countries there is no question that these sources of energy, today, are very important components and play an important role in energy policy.

Why should industrialized and developing countries be interested in these sources of energy? That is a very important question that should be answered by the Conference. In the case of industrialized countries where everybody agrees that the role of these sources is very limited and will continue to be limited in the years ahead, I think maybe the most important argument to persuade them to participate in this is that no country can afford not to think ahead. To continue thinking scientifically, technologically, economically, and even morally is a major responsibility of the whole world. Another factor which is very important in the short-run is that behind many of these renewable sources of energy, there are big commercial and industrial interests. Leaving aside this very legitimate interest, I think that the major concern of industrialized countries should be based on the fact that a future market exists and everyone should be interested in what is going to happen in the decades ahead. That is, I think, enough to sustain their responsibility vis-a-vis these sources of energy.

When we come to developing countries, the situation is a little bit different. I think that the argument to look ahead and to pay attention realistically to these sources of energy stems from three or four points. There is a phenomenal projection of the amount of energy the developing countries of the world will need in the coming years.

In the first place, the unavoidable relation between industrial-technological development and energy exists. No matter how the developing countries have evolved in the past, we are faced today with the fact that their populations are growing very rapidly and at the same time are aspiring to technical development and economic progress. The per-capita use of energy is even now very low, and thus to supply more energy to allow both population growth and development is a tremendous problem requiring an increase in energy availability in the Third World by a factor of two or three. These countries must rely on an expanded use of conventional sources, conservation efforts, and the new and renewable sources of energy. Only through a mixture of all of these sources can Third World countries hope to find a solution to their energy problems. This fact, alone, should provide a great stimulus for interest in new and renewable sources of energy.

The second element that to my mind makes these sources of energy viable and useful involves the population distributions and economic structures of the Third World. Fully 60-70% of the population are scattered over wide areas in the rural regions and depend largely on local sources of energy. The fuelwood crisis in many rural areas is a very good example of the severe situation facing the rural population. The fuelwood problem is a major crisis that must be emphasized at the Conference.

The great urbanization process that is taking place in Latin America is another problem and a tremendous challenge. Fully 80% of that continent's population will soon be located in urban centres and cities, some of them the biggest in the world. What are we going to do? This is something which is not much spoken of. As few speak about the fuelwood crisis, so it is with the urban crisis. How can the sources of energy that this conference is considering deal with the urban crisis in the developing countries? This is a very difficult question and the role of these sources in this case is as yet quite unclear.

In planning for the future and in searching for new forms of energy the whole process must be approached in a planned and unified manner. The options must be considered from an integrated perspective. As an example, you cannot develop an alcohol programme by only establishing one or two distilleries. Much more than that is involved including the whole system of transportation, financing, and technology. So, when I look at renewable sources of energy, I always try to base planning on an integrated foundation. Economic, social, environmental considerations must all come into play when looking at these sources for the future.

We are used to speaking of energy as an input into development - sometimes as a passive input. When we consider new sources of energy we are much closer to the opposite relationship - development as an input to energy. I am very pleased to notice that many governments have accepted, in spite of some disagreement, the following concept:

> "Like any energy source or product, new and renewable sources of energy are themselves both an 'input' and an 'output' of the development process, not tangential to it."

A great amount of work needs to be done to understand and expand on this concept. When we engage in agricultural activity to create biomass, we are participating in development as well as producing energy. When we organize the social forces around the construction of biodigesters, we are also organizing the social forces for development. This is a very important concept. There is a tremendous environmental advantage in these renewable sources of energy and this element should also be appreciated and a part of our total vision of these sources. These potentials should be integrated in the governmental perspective to the global approach to energy. We cannot wait for the whole world to change its international relationships and national structures to do something.

Identification of Areas for International Action

If you were to ask me what this Conference could achieve through international action in Nairobi, I would say four things. First of all, awareness. Awareness is without question a very important element of the United Nations and its programmes. The United Nations has a very important potential to give legitimacy, credibility and viability to certain ideas. The United Nations should use its credibility to alert the world of the need to tackle energy problems seriously, collectively and in a co-operative manner. If we succeed in doing only this, we will have made a major contribution to the world and will have justified the convening of this Conference.

Secondly, this Conference should give a clear message and stimulation to national Governments to: make assessments of resources; train and educate people so they can have real options; and prepare people to make the appropriate decisions when they absorb or try to introduce new technologies. All this is part of the national commitment which I think is an important role for the Conference. But we must also identify certain priority areas for international co-operation. The first one, of course, would be to help developing countries to organize themselves for the purpose of co-operation in training, information and assessment.

We must work politically to develop and advance technologies and to test and demonstrate them. The developing countries do not want to be the guinea pigs for untested or unproven technologies. It is a very important role of the UN to help them to make the right selections and not to be merely the victims of new commercial and industrial products. A third area of co-operation involves the rural sector. I think the Conference will make a very important contribution in this area.

Last, but not least, we expect that this Conference will help to mobilize the international bureaucracy, which has a tremendous potential to achieve certain things. I hope that through the convening of this Conference we can help the UN system to be more effectively organized to face the challenges of energy development and use.

The Conference could be a historic event and a very important step towards a serious treatment and discussion of the energy field in the international community.

CONFERENCE SECRETARIAT AND UN UNIVERSITY ORGANIZE DISCUSSION PANELS

With the assistance of five agencies of the United Nations, the UNCNRSE Secretariat and the United Nations University are planning a series of panel meetings on specific topics during the Conference. These panels will provide a forum parallel to the Conference for discussions and exchanges of views on specific aspects of the energy situation of particular interest to the sponsoring agencies by eminent specialists, members of national delegations and the non-governmental organizations, and interested journalists - in their personal capacities.

These panels will be convened at the Kenyatta Conference Centre from 1700 to 1930 hours to enable participants in the Conference and the NGO Forum to attend. Each panel will include four eminent and highly qualified panelists who will each make 15-minute presentations, an outstanding journalist who will act as commentator, and a chairman/moderator who will be the executive head or a high official of the sponsoring organization. Most of the last hour of each meeting will be devoted to the discussions or opinions expressed by the panel. It is planned that the proceedings of these panels will be published after the Conference by the Secretariat and the United Nations University.

Members of delegations, non-governmental organizations and the press who wish to participate in the discussions will have the opportunity to register with the panel office in the Conference Secretariat before 1200 hours on the date of the respective panel.

PANEL SCHEDULE

Date		Topic	Sponsor	Chairman
Tuesday	11 August	Energy and Society	UNESCO	Amadou-Mahtar M'Bow
Thursday	13 August	Energy and Agricultural Development	FAO	D.F.R. Bommer
Friday	14 August	Energy and Industry	UNIDO	Abd-El Rahman Khane
Monday	17 August	Energy and Environment	UNEP	Mostafa K. Tolba
Tuesday	18 August	Energy and Human Settlements	UNCHS	Arcot Ramachandran

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sion to liquid fuels and direct combustion, have promise in a number of countries, especially those with under-used agricultural and forest resources and tropical climates. However, a rapid expansion of biomass-based energy poses special social dangers. If pursued without proper planning and safeguards, biomass-based energy could compare with food for agricultural resources, driving up food prices and having devastating effects on the poor. Biomass programmes should be developed with the utmost caution, with social and ecological ramifications taken thoroughly into account.

Because of the magnitude of their near-term contributions and (in one case) because of potential dangers, we have drawn special attention to just three of the fourteen energy sources under consideration at Nairobi: fuelwood, hydropower and biomass. However, the technical documentation for the Conference has shown that for each of the major categories of energy need (liquid transport fuels, centralized electric power, decentralized electric and shaft power, and heating and cooling) a variety of new and renewable energy technologies will, over the next two decades, provide competitive alternatives under certain conditions. For example, small-scale hydropower can provide decentralized electricity or mechanical power or feed into a grid; likewise for wind power in appropriate sites. Solar crop drying and water heating may have widespread utility. As their cost falls, photovoltaic cells may become competitive in a widening variety of situations where decentralized electric power is desired. Geothermal power, oil shale, tar sands, and perhaps ocean thermal energy conversion will all make contributions in the decades ahead.

The list could go on. The important point is that countries face increasingly diverse and complex choices in the energy area. The days when inexpensive oil could be expected to meet virtually all rising energy demands are gone. Now countries must take stock of their own reserves of conventional resources, make assumptions about future international energy prices, examine their ecological capacities for exploiting a variety of new and renewable sources, and then make energy policy choices that in turn fit in with development goals.

It is not possible to say just what priority new and renewable energy should receive versus conventional or other sources in a given country. Each country must have the capacity to analyse energy issues and to make appropriate choices. The potential for wasting scarce resources on uneconomic, technically immature sources is great. Energy policy implementation, too, is far more complex in an era when a multitude of sources, decentralized as well as centralized, must be developed. Wider use of new and renewable energy requires a greater diversity of skills, and greater public knowledge and participation, than has been true of energy production in the past.

3. Selected Action Proposals

The technologies considered within the scope of the UN Conference are extremely heterogeneous, as are the potential ecological and cultural conditions of their use. No simple programme can provide the right support to all these varying technologies and needs. Instead, the Conference should try to promote more general approaches and activities that will accelerate the development of new and renewable energy as appropriate in each locale. While the major responsibility for progress with new and renewable energy must lie at the national level, well-designed regional and global activities can provide useful support. Also, the recommendations of the Conference should not be limited to UN activities; efforts to stimulate appropriate actions in the private sector are desirable.

National Level

Each country should initiate a process of comprehensive energy assessment, analysing demand patterns, potential domestic energy resources, and alternative strategies for satisfying needs in a socially, environmentally, and economically sound manner. These assessments should be dynamic and ongoing, rather than one-time efforts to settle energy policy issues. Although many developing countries will require outside assistance in carrying out assessments, the involvement and training of indigenous personnel should be stressed so that the national capacity to carry on with assessment and planning is strengthened.

As part of this assessment process each country should survey its resource base for new and renewable energy. Basic data including wind patterns, solar insolation, biomass potentials, forest productivity, ocean thermal gradients, geothermal resources, small- and large-scale hydro potential should be collected as soon as possible to provide a solid foundation for energy planning.

All countries should develop an over-all energy plan. Within that broader framework, specific goals and strategies for new and renewable sources should be developed. Many renewable energy technologies face particular institutional or social barriers that require non-traditional policy measures. Since some renewable technologies are effective only in conjunction with energy conservation measures, a renewable strategy must include attention to energy efficiency as well. National plans for new and renewable energy might include:

- Production targets for relevant energy sources that are technically mature, with workplans for attaining them.

- The promotion of institutions, public or private, for research, development, adaptation, and demonstration of renewable energy technologies as appropriate to national needs and capacities. While much advanced technology can and should be obtained internationally, nothing can substitute for indigenous capacities to adapt and experiment in local cultural and economic settings. Facilities for gaining access to technical information generated abroad should be developed in conjunction with research institutions. Research on neglected topics of particular concern to the rural poor, such as draft animal power and natural forest management, should be pursued.

- Measures to accelerate the training of needed personnel at all levels.
- Public education on energy issues and renewable energy and conservation possibilities, including the introduction of these topics into school curricula, general public education campaigns, and extension activities aimed at potential uses of cost-effective renewable energy and conservation technologies.
- Restructuring of tax and price policies, building codes, and other regulations to eliminate disincentives to the adoption of renewable and conservation technologies.
- Fiscal incentives and subsidies to encourage use of renewable energy sources and conservation where market mechanisms fail to reflect the true long-term costs and benefits of energy alternatives. The unusually high up-front capital cost of many renewable technologies often justifies special credit measures or subsidies.
- Formal environmental and social impact assessment procedures that will precede all significant energy policy and investment decisions.

Regional Level

In principal, regional-level co-operation and planning can provide useful support for national action and also allow collective activities beyond the reach of individual states. In practice, regional programmes frequently fail to live up to their promise. Often it turns out that the interests of countries within a region are more disparate than expected; smaller, sub-regional groupings can in some cases be more relevant to country needs.

With new and renewable energy, the goal should be to nurture and take advantage of regional and sub-regional initiatives wherever the preconditions for success appear to exist, while recognizing that their feasibility varies widely. Possible regional measures include: regional plans of action, co-operative research and development, information exchange, technical assistance, training, and co-ordination of production facilities.

Global Level

Finance

The true shortage facing developing countries is not one of energy resources but of capital. With adequate finance, any country could develop or import the fuels it requires for development. The question of finance is the overriding issue in any discussion of energy and development. The damage of growth in the developing countries would be reduced if the era of cheap and abundant energy were to be succeeded by an era of adequate and moderately priced finance. Those who benefited most from the previous availability of low-cost energy have a moral obligation in this respect to the latecomers to development, who can never enjoy the advantages of the past era. Everywhere, energy investments require a higher share of available capital formation than in the past. For developing countries that are already short of capital, the energy problem puts them at an even greater economic disadvantage.

Large amounts of additional finance are needed to support investments in energy production, to help develop new technological capacities, and to provide necessary technical assistance. The first of these - investment needs - requires, of course, by far the greatest funding. The total energy investment needs in the developing countries over the next decade are US$60-80 billion per year, of which renewable energy may account for new and renewable sources in isolation from the total need. Despite the limited scope of the Nairobi Conference, it may be counterproductive to establish new funds that can support new and renewable energy alone.

Our group wishes to present a variety of ideas on ways to mobilize additional funds for developing-country energy investment:

- The lending capacity of the World Bank could be increased by changing the capital-lending ratio, or gearing ratio, from its extremely conservative level of one-to-one.
- The resources and contributions to energy investment of the regional development banks could be augmented.
- A new energy-investment bank could be established by OPEC, OECD, and other countries.
- Innovative corporations combining public with private capital appear to offer promise. These could invest directly or act as intermediaries, mobilizing private funds for sound projects.
- Consortia of commercial banks could form their own energy affiliates.
- Special corporations modelled on the Tennessee Valley Authority might provide means of exploiting the energy and development potentials of large river basins, and

these could be international in character where more than one country is involved.

- Investment guarantee schemes could help to mobilize additional private capital for energy investments.

- Other possible innovations such as an energy tax, guaranteed energy bonds using surplus OPEC capital, and a Third Window of the World Bank, providing loans with subsidized interest rates to intermediate-level developing countries could be considered.

- A Consultative Group on Energy Investment should be established, which would draw together major lenders and development assistance donors from all sectors to consider needs and mobilize the capital and technical resources required to meet them.

Improved means of financing the improvement of energy-related technological capacities in developing countries are discussed below in the section on research and development. Finally, it should be stressed that, in order to make energy investments wisely, many developing countries need technical help with energy assessment and planning. The needs for technical assistance must be built into all energy financing operations.

Global R & D Co-ordination

New and renewable energy research is expanding rapidly world-wide, but co-ordination and information sharing are poor, duplication is widespread, and some subjects of importance to developing countries are receiving few research funds. The bulk of current research is in developed countries; many of the results will not be useful in developing countries without further adaptation.

The challenge to the UN Conference is to find a way to fill the research gaps and speed up the dissemination of results without undermining the vitality of existing institutions or discouraging local initiative. Emphasis should be placed on strengthening indigenous technological capacities in developing countries.

A global co-operative effort in research and development on new and renewable energy should meet the following criteria:

- It should tap the creativity and local knowledge of decentralized research and adaptation efforts.

- It should promote the emergence of stronger national technological capacities in developing countries.

- It should involve support for non-governmental as well as official institutions.

- It should facilitate the global sharing of research results.

- Arrangements should be flexible enough to take into account the differing needs of different technologies. (Some are amenable to centralized institutional research, whereas others can only be developed in a decentralized manner. Some are adequately covered by existing developed-country programmes; others of interest to poor countries are relatively neglected.)

- It should provide a mechanism for setting priorities among and within technology areas.

- It should provide a means for mobilizing increased financial aid from governments, foundations, and donor agencies, and for directing them towards the priority needs.

These goals could be met through the establishment of a global research and development co-ordinating mechanism closely linked to the other technical assistance, information exchange, and training activities that will be promoted by the UN system. A small central research and development secretariat could be established, but the main innovation would be the formation of an expert consultative group including representatives of major donors and of public and private organizations involved in research and applications. This group could function as a sub-group of the broader consultative group in energy investment called for above. The over-all goal would be the creation of a flexible structure that provides the benefits of a global strategy but that preserves the benefits of decentralized research.

The consultative group could, like that for agricultural research, attempt to mobilize additional private and public funds. It could monitor research trends, identify gaps, and attempt to channel resources in appropriate directions. Particular emphasis could be put on strengthening national and regional institutions in developing countries. The secretariat could also support the development of methodologies for technology selection, and establish uniform global performance criteria and standards for new and renewable energy equipment.

One area for which current research is clearly inadequate is biomass-based energy. The growing of crops and trees for direct energy use, or for conversion to liquid fuels, is at a primitive state technically. Opportunities for growing energy crops on marginal lands, where they would not displace food output, have scarcely been explored. Neither traditional crop-research techniques nor new biotechnologies have yet been fully applied. Advanced research on technologies for converting biomass to liquid fuels, and for using these fuels efficiently, also has a high potential payoff. Research on interactions between the food and fuel sectors, and on ways to minimize competition, is necessary.

Thus a special global research and development programme on biomass-based energy is warranted. Much of the actual plant research must be decentralized, while some of the research on conversion techniques and with genetic engineering can be more concentrated in leading universities. A concerted, mission-oriented global programme of research and development on biomass energy could either be the main focus of the secretariat called for above, or could justify a new institution. If a new research centre were established, it would, from the outset, need to emphasize global co-ordination and the encouragement of decentralized research as much as its own research programme.

Technology Transfer

New and renewable energy assistance should be designed to help poor countries acquire the ability to develop and adapt technologies relevant to their needs. Donors should also support the establishment of indigenous industries for the production of renewable energy technologies and equipment where it is feasible to do so. Joint ventures of international and developing-country firms may offer mutual benefits.

There is a danger that, as technical breakthroughs occur and the demand for renewable technologies grows, more and more essential information will be treated as proprietary. In fact (much as has begun to happen in the genetic engineering field), even academic scientists could begin to stress the commercial potential of their work and choke off the traditional free exchange of scientific research.

Proprietary technologies, and the incentives for research their existence provides, clearly have a legitimate role in international commerce and energy development. Governments should act to facilitate communication between technology holders and potential users, encouraging access on the best feasible terms for developing countries in particular. At the same time, however, governments should ensure open access to knowledge and technologies developed with public funds, and in general encourage the freest possible international exchange of the results of research, development and demonstration programme.

Fuelwood Programme

The problems of fuelwood supply have generally been neglected by national development planners as well as international donors. For example, a mere one percent of the Western aid to the wood-short countries of the Sahel in the second half of the 1970s went to forestry. However, as wood supplied become depleted in spreading areas of Africa, Asia and Latin America, the negative human and environmental consequences have become too great to ignore. Within the last five years, governments and donor agencies have begun to devote more resources to this problem. The UN Conference, by calling explicit attention to the fuelwood problem and establishing a global action plan to meet it, could have a catalytic impact, accelerating the responses already in motion. A special commitment to meeting the most basic energy needs of the world's poor should unify all political groupings.

Recent analyses by the World Bank have shown that the planting of fast-growing trees is in many areas the most cost-effective way of meeting household fuel needs. On average, the rate of tree planting in developing countries must multiply ten-fold if severe economic, social, and ecological dislocations are to be avoided. Closing this gap requires a complex array of forestry activities, such as large-scale plantation of urban areas, village woodlots, private woodlots, and the integration of forestry into agricultural systems.

Major attention must be given to the development of indigenous institutions able to manage forestry and to involving the public in a manner that is crucial to success. Special efforts are needed to involve women - the main collectors and users of wood - in forestry activities. The development and dissemination of improved cooking stoves, which can cut wood use by half or more, are just as urgent as tree-planting. International and local research on fast-growing tree species, on native species and the productivity of natural forests, and on charcoal production techniques are called for. Finally, the potential for greater use of fuelwood substitutes such as biogas and coal should be explored.

Even if ample funds were available, institutional weaknesses in the developing countries would not permit tree planting at the needed rates in the near term. Rather, over the next five years, donors should concentrate on building the institutions and gaining the experience needed for another significant expansion of efforts in the late 1980s. A desirable goal is to build up to an annual investment level of US$1 billion per year within the next few years, compared to current investments of well below half that level. Thus total fuelwood-related investments over the next five years should be at least US$4 billion - of which the World Bank would put up at least US$1.5 billion, other donors US$1.0 billion, and developing countries US$1.5 billion in local currencies. Effective action to provide sustainable, low-cost domestic fuel will have a human impact much greater than the relatively small amounts of energy and finance involved would suggest.

UN Institutional Follow-up

Some institutional means within the UN system for following up on the Conference programme of action is essential. UN activities in such areas as training and information flows will have to be managed. The energy activities of the various agencies of the UN system need to be better co-ordinated. The UN should provide improved statistics and periodic assessments of the status and use of new and renewable energy sources.

Possible measures range from a reorganization of personnel within the UN Secretariat to the establishment of a new office reporting directly to the General Assembly. The direct appointment by the General Assembly of a high-level individual who has strong international backing to oversee all UN energy efforts would seem to be the best way to ensure strong follow-up, given the fact that major new institutional initiatives are not likely under present conditions.

A serious problem with any approach is, again, the irrationally limited scope of the Nairobi Conference. Innovations in support of new and renewable sources should be the starting point in a process that leads to global action on the entire range of energy sources and problems. Clearly, the Nairobi Conference cannot itself give birth to comprehensive energy institutions and financial arrangements, but it can be a positive step in that direction. Nothing less will do.

* Mr. Maurice Strong is Chairman of the International Energy Development Corporation, Geneva, Switzerland. Mr. Mahbub ul Haq is Director of the Department of Policy Planning and Program Review of the World Bank, Washington, DC, USA.

ENERGY IN THE NORTH-SOUTH DIALOGUE:
A PRIVATE SECTOR PERSPECTIVE

Sam Schwartz
Group Senior Vice-President, Conoco, Inc.
High Ridge Park, Stamford, CT 06904, USA

From a private sector perspective, extensive interaction between North and South on energy issues, although beset with controversy, is necessary and desirable. Industry, as it copes with the daily problems of energy supply and demand, is acutely aware of the interdependence that exists between North and South in this crucial area. It seeks to achieve greater understanding of the workings of that interdependence and of the most effective ways to achieve positive results from it. This is not an easy task given the multitude of political and economic - let alone practical - problems that must be addressed. Yet efforts to achieve progress at both the level of global negotiations and practical *ad hoc* accommodations must proceed. The purpose of this article is to suggest how progress can be made in addressing the energy needs of the developing world through greater utilization of the resources of the private sector.

At best, constructive discussion of the energy issue - complicated by conflicting national interests and confused by the influence of energy considerations upon other topics on the agenda - proves difficult. But it is especially so at the level of formal, global negotiation. Moreover, the atmosphere in the 1980's may prove even less conducive to positive approaches to the energy problem at the global level. Differences among countries are likely to be exacerbated by several factors: the unwillingness or incapacity within OPEC to produce at levels reached in the late 1970's; the uncertain availability of oil from other sources; the rapid escalation of production costs, which will add more pressure to rising oil prices; and the increased difficulty of recycling petrodollars.

Based on these considerations, near-term prospects of concrete results from a formal level of dialogue on energy appear very limited. Precisely because of this, the need for informal practical co-operation among industrialized and developing countries assumes enhanced importance. It is at this level that private industry can play its most effective role as a problem-solver.

1. The Elements of Consensus

Although formal negotiations on energy have achieved only minimal policy solutions, an informal consensus is emerging on various aspects of the energy problem and on some of the steps which need to be taken. Elements of this consensus include:

(a) Agreement that energy is a global problem, including recognition that the energy market is indeed international in nature and that energy-related events in industrialized and developing countries have interlocking effects.

(b) Recognition of the fact that the world as a whole is overly dependent on oil as its primary energy resource and that sooner, rather than later, a prolonged shortfall in oil supplies could occur.

(c) Acceptance of the fact that in order to ensure a smooth transition to greater reliance on other sources of energy, action must be taken now to:

- conserve available supplies of petroleum;
- identify and develop all possible new sources of petroleum;
- substitute other energy sources for oil whenever possible; and
- accelerate the longer-term use of renewable energy resources.

(d) Realization that despite the lack of a global energy agreement, much can and should be done by governments, international institutions, and private industry to expand exploration for and development of all types of energy resources and provide the technical assistance and financial resources necessary to encourage transition to a more balanced energy mix in the world (even though petroleum will remain the dominant ingredient in that mix well into the next century).

In addition to growing agreement on these general aspects of the energy problem, considerable consensus exists on the need to increase energy production in oil-importing developing countries. Consensus on the oil-importing developing-country aspect of the energy problem has resulted in several important initiatives that serve, among other things, as a bridge between North-South interaction at the informal level and the presently stalemated formal global negotiations. These initiatives include the Brandt Commission, the World Bank energy programme, and the activities of the United Nations specialized agencies.

Initiatives such as these, wisely formulated and implemented, would allow continued progress at the informal level of the North-South dialogue, even as stalemate continues in global negotiations. These measures would, however, fall short of their potential contribution unless a mutual reinforcement took place with the efforts of the private sector. If the World Bank, UN, and other non-private initiatives were to compete with or seek to replace private sector activities, the net result could be a reduction of the private-sector energy contribution in the non-OPEC developing world at a time when the need for such contribution would be increasing. To avoid such an unintended result, several general goals should be sought in implementing public-sector programmes:

(a) International energy programmes should provide for increased co-ordination with the private sector in order to capitalize on its technological expertise and practical problem-solving orientation and to avoid wasteful duplication or utilization of limited resources in "dead-end" areas.

(b) Non-private sector initiatives should be designed to encourage a more compatible relationship between developing countries, where the government is the primary actor, and the private foreign investment community. Particularly important would be the promotion of long-term stability through contractual arrangements providing a high element of predictability for all involved parties. It is highly unlikely that the private sector will accept significantly greater exposure in developing countries unless it is convinced that the original basis for a decision to proceed with a project will persist throughout the life of the project. Without such assurance, the risk-taking propensity of the private sector often markedly diminishes in just those developing environments where there is acute need for additional energy initiatives.

(c) In selected cases of "high-risk" undertakings, World Bank and other programmes might justifiably provide developing countries with the financial assistance necessary to allow a host government to assume a greater proportion of the financial burden relative to that of the private company involved. This is especially necessary when the energy resource to be developed is small and is likely to be utilized for domestic needs only. Under such conditions, greater-than-normal World Bank financing for the host government may be the necessary precondition for a project to proceed.

(d) There should be active solicitation of greater private-sector involvement in publicly funded energy assistance projects.

(e) New financial mechanisms for energy assistance should be predicated upon total available resources, and information about these mechanisms should be freely available. In essence, the goal here should be to make public funds available in a manner complementary to rather than competitive with the activities of the private sector.

(f) Energy assistance programmes should be designed to encourage more realistic market pricing of energy resources in developing countries. At a time when long-term relative energy scarcity in many countries is all too evident, subsidization of energy consumption results ultimately in skewed economic decisions that ill-serve the long-term interests of developing countries. That this is a hard lesson for any country to learn is evidenced by the situation in my own country, the United States.

(g) Careful attention should also be given in energy assistance programmes to increasing the capacity of developing countries to absorb the energy technologies and capacities being developed. Training programmes, demonstration projects, information exchange and institutional development can promote such absorption.

2. Strengthening the Informal Dialogue: Private Sector-Developing Country Attitudes

Conditions and attitudes in both developing countries and the foreign investment community seem conducive to the expansion of direct, mutually beneficial arrangements between the developing countries and the private-investment community. On the latter's part there is increasing recognition of the importance of dove-tailing energy projects in the developing countries with their over-all developmental objectives. "Social responsibility" has become much more than just a catch phrase in corporate planning. A conscious effort is being made to understand the needs and priorities of developing countries and to formulate investment strategies that result in a meaningful contribution to those needs. This process is obviously facilitated when developing countries clearly state their desired objectives.

Host countries also will gain by the realization that they will receive an optimal contribution to their development efforts from private foreign investors only when the latter can be assured of a reasonable return on investment and of reasonably stable terms and conditions for doing business. The latter requirements are especially important when projects have long lead times. In this regard, it is worth noting that, despite the strident political rhetoric encountered at times in the formal North-South dialogue, various developing countries - including some avowedly socialist ones - which have undergone periods of extreme economic nationalism, are now looking for ways to renew foreign investor interest in their development. Hopefully, the xenophobic phase of "economic nationalism" will dissipate and allow a substantial increase in mutually beneficial efforts to grapple with energy and other problems that are truly global in nature.

If a better approach to private sector-developing country interaction evolves, technical assistance in the energy area appears likely to be one of the most promising avenues. Therefore, we believe that formal bilateral and multilateral development entities should be encouraged to provide information to private industry regarding technical assistance programmes in energy for developing countries, and to consult on how to design and implement such efforts. As part of this process, areas where private industry could make contributions "in kind" may be identified. Programmes to provide technical training for developing country nationals are one area where useful private sector input can be envisioned. For example, technical-training programmes could include on-site courses in the operating, administrative, or R&D facilities of a private company. Some such programmes already exist and can be expanded. Another approach would be to invite private-sector experts to participate in or provide materials for training programmes undertaken in developing countries.

Private industry can also play an expanded role in providing technical advice and information on specific developing-country energy problems. Such advice might encompass a broad variety of topics such as interpretation of seismic data related to petroleum and non-petroleum resources; techniques to improve energy efficiency in industry or residential sectors; optimal energy delivery systems; and information on the costs and technical aspects of available technologies to tap various energy resources.

Industry Support for Technology Commercialization Efforts. Energy assistance and commercialization goals would both be served by a greater involvement of private industry in designing and implementing energy technology projects for use in developing countries. For example, projects to demonstrate renewable energy technologies adapted to developing country environments could draw on the resources and expertise of the private sector as well as on those of public development assistance agencies. This approach may be particularly relevant in the area of renewable energy, but in some cases it could be applied to non-renewable energy resources as well, e.g. to tar sands, heavy crude oil, shale oil and coal.

Government Co-ordination with the Private Sector. In the formulation of policies related to energy in the informal North-South dialogue, private business perspectives can be included through the use of public-private sector co-ordination mechanisms. For example, in the United States we have a private-sector Working Group on U.S. Preparations for the UN Conference on New and Renewable Sources of Energy, which is one example of a co-ordinating mechanism which has promoted better mutual understanding on practical issues and a realistic appreciation of the limits as well of the opportunities involved in such co-operation. A similar approach might be attempted with respect to energy concerns in the North-South dialogue.

In the absence of a formal co-ordinating mechanism, other kinds of consultation should be considered. Regular briefings of private sector groups by policy makers on North-South energy developments should be scheduled. Experts in industry should be consulted for technical or policy-related advice as the need arises. When meetings or conferences take place to discuss initiatives at the informal level of the North-South dialogue, private sector representatives should be included as members or advisors to delegations. Obstacles to some of these measures may exist. Nevertheless, it is difficult to believe that they are insurmountable given the positive results that would flow from closer co-ordination between the private and public sectors.

Removing Disincentives to Foreign Investment in Energy and Balancing Risks with Potential Gains. The magnitude of existing need for the exploration and development of energy resources in developing countries suggests that the private sector will continue to play an important role in providing the requisite financial resources, managerial expertise, and technical knowledge. One method for achieving greater immediate and concrete response from the private sector to the need for expanded energy activities in developing countries is to remove disincentives.

Government in the industrialized countries should encourage more rational operating environments for foreign investment in developing countries. It is clear that a frontal assault on "economic nationalism" in developing and industrialized countries alike is unlikely to yield meaningful results. However, in programmes designed to assist developing countries to cope with their energy problems, donor governments are not precluded from implying that such assistance is predicated on hospitability to private investors. This can be accomplished through bilateral treaties which recognize and effectuate the rights under international law of foreign investors, and through support of such endeavours as the OECD Guidelines, calling as they do for national treatment - that is, for treating foreign-based enterprises no less favourably than domestic enterprises.

In addition, host governments can be urged to recognize certain basic responsibilities towards foreign investors:

(a) Uniform observance and implementation of domestic legislation, taking the long-term perspective with multinational enterprises. This would ensure predictability in the legal system.

(b) Commitment to maintain long-term bilateral and multilateral agreements relating to multilateral enterprises.

(c) Respect for contractual terms and of established rules applicable to contract modification.

(d) Prompt, adequate and effective compensation for expropriation.

(e) Recognition of the need for business confidentiality in regard to information disclosure requirements.

(f) Agreement to mutually acceptable investment dispute settlement mechanisms.

In many cases there is a preference on the part of developing-country host governments to deal with public sector counterparts in the industrialized countries with market economics. As a consequence, in the United States at least, foreign-assistance programmes have reflected a desire on the part of some to distance these programmes from the US private-investment community. Such an approach makes little sense in the over-all development context and even less sense in the energy area where utilization of the expertise and technology of the energy industry could be the key to successful undertakings.

Actions taken along the lines suggested will provide a positive incentive for private industry to involve itself more deeply in North-South energy issues despite the existence of significant areas of business uncertainty. Presently, extreme caution and hesitancy in the private sector towards North-South undertakings is giving way to a willingness to examine the issues on a pragmatic basis. For example, the US energy industry views World Bank initiatives in the energy area as possibly providing enhanced opportunities for the industry as well as for the developing countries if such initiatives are undertaken in harmony with the principles outlined above. Moreover, whereas private industry once viewed UN conferences with indifference or outright animosity, its willingness to become involved in preparations for the UN Conference on New and Renewable Sources of Energy and the UN Symposium on World Coal Prospects reflects growing acceptance of the usefulness of such forums for improving mutual understanding with developing country governments.

It is certainly desirable that this trend continue. Private industry, motivated by an understandable commercial desire to expand its involvement in North-South energy developments, has much to offer the developing world in terms of appropriate technology, technical assistance, and training.

3. Conclusion

Under present conditions, co-operation at the informal level of the North-South dialogue on energy appears to offer the greatest opportunity for progress, and it will be increasingly important in achieving effective solutions for global energy problems. For this reason, it is to be hoped that governments in both industrialized and developing countries, international institutions, and private industry will all give greater attention to strengthening the dialogue at this level. This is not to argue that formal global negotiations should be abandoned; it suggests rather that success at the global level may have to wait upon a wider experience of successful partnership arrangements at the informal practical level between developing countries and private industry in the industrialized countries with market economies.

IV. TECHNICAL AND ECONOMIC ISSUES

SOLAR ENERGY: TWILIGHT OR DAWN?

Anil Agarwal
Centre for Science and Environment
New Delhi, India

Todd Bartlem and Thomas Hoffmann
International Institute for Environment and Development
1319 F St., N.W., 8th Floor, Washington, DC 20004, USA

As the time remaining before the United Nations Conference on New and Renewable Sources of Energy (UNCNRSE) disappears, it is increasingly urgent to focus attention on a few central issues where action and achievement are possible. During the 1970s, political commitment to renewable energy sources has grown progressively. It is now commonplace wisdom in many countries - especially in the oil-importing countries - to replace oil with domestically available energy resources wherever possible. In fact, the last round of oil price increases may already have pre-empted the original objective of the UNCNRSE to create greater global awareness of the importance of renewable energy sources.

The most important goal in Nairobi should be to begin transforming renewable energy from a distant promise into a viable policy option. The enthusiasm generated by the Conference should not be allowed to obscure the fact that comparatively little work has been done to identify the practical steps towards a renewable-energy future. Unwarranted promotion has to be set aside in favour of hard-headed analyses. The renewable-energy option should be chosen wherever it is feasible, but it should also be postponed without hesitation when its economic viability or technological feasibility is in doubt.

A variety of studies have been published in recent years advocating increased use of renewable energy sources and arguing for proper recognition of their role by national energy planning systems and by international and bilateral institutions in their lending programmes. However, a study by the International Institute for Environment and Development[1] recently concluded that promotional activity by aid agencies as well as solar energy companies has not been fully justified by the state of readiness of solar energy technologies. Although the development of renewable-energy technology and its application to the problems of developing countries are areas where co-operation might prove to be mutually beneficial to the North, South and OPEC, it must be pointed out that the solar energy industries in the industrialized countries have based their sales strategies on misconceived expectations about the potential market and operational conditions in developing countries.[2] In a few years, these hopes may seem realistic or even modest. But today, many renewable-energy companies are floundering in search of buyers who can afford their relatively expensive technologies. It is extremely significant that most of the renewable-energy technologies have been researched and developed in the industrialized countries, especially by the large multinational companies. However, the existing lack of markets means that the renewable-energy companies may be readily encouraged to attempt the transfer of new, and often unproved, technologies and products to developing countries.

Problems related to technology transfer have not been adequately discussed in renewable-energy debates. In particular, there has been no detailed analysis of the implications of various technology policies associated with a strong commitment to renewable-energy sources by a developing economy. Generally, technology transfer refers to the process by which a country, or one of its companies possessing a technology, transfers the technology (or the know-how to produce it) to a country or one of its companies that may have a need for that technology. The transfer process should ideally be such that it contributes to the over-all economic development goals of the recipient country.

The special characteristics of renewable-energy technologies will determine several critical elements of the transfer process. Many of these technologies still are in an intensive research and development stage and, therefore, are changing rapidly as new systems and processes are actively explored by northern governments and industries. For a Third World planner, the pace of technological change in the field of renewable energy poses a particularly serious question: should limited research and development resources be invested in such a rapidly moving field if there are few guarantees that this research and development investment will generate sufficient returns for the nation? Can a developing country establish a competitive up-to-date technological capacity of its own in such a fast-moving environment? It is likewise worth noting that renewable-energy systems may offer greater opportunities for technological self-reliance in developing countries than most conventional energy systems such as oil, coal or nuclear-fired power plants.

Secondly, renewable-energy technologies can be easily divided into two types: (a) less sophisticated technologies using sources such as firewood and biogas plants, and (b) highly sophisticated technologies such as solar cells. The former technologies have proved to be extremely sensitive to such micro-economic and social conditions as the level and nature of community organization at the site of application. The latter technologies too will have major social and economic implications for the societies in which they are applied. However, they do appear to be more amenable to transnational application and commerce. Unfortunately, it is precisely these latter technologies which require a great deal of capital investment (invariably greater per unit of energy delivered than for nuclear-power generation technologies). Yet, because of the extremely low operational costs and the opportunities for decentralized applications, many such technologies will become economically viable for a variety of applications, even while capital intensity remains very high. In other words, many forms of solar technologies may become "cheap" for remote, small-scale uses, but their widespread utilization will still be financially impossible.

Despite these problems which are associated with technology transfer in the solar energy field, it is surely an urgent priority for global development that renewable-energy technologies be utilized in the developing countries. Energy independence is widely regarded as a desirable political and economic goal in almost all countries of the North and the South. Renewable energy sources offer greater possibilities for achieving energy independence, and their advocates have repeatedly pointed out this advantage. It is important, therefore, to facilitate the transfer of renewable-energy technology and to create innovative means to do so. It might even be necessary to achieve substantial cost reductions and to enable developing countries to adapt and utilize the new energy technologies on the widest possible scale.

But while the sun may be freely available, access to the technologies needed to reap its bounties is not. Most developing countries have experienced mounting oil bills, adverse balances of payments, and many have also been facing worsening terms of trade in the world market for their commodities. They do not at this time possess substantial foreign-exchange reserves. It would be extremely difficult for non-oil-producing, industrially developing countries to import renewable-energy technologies on any really significant scale in hard foreign exchange. Consequently many countries which need to make the solar energy transition first will probably make it last, unless of course they try to borrow further from international institutions and private banks, thereby increasing their already overstretched indebtedness. A technology-transfer system in which there is no other alternative but to import expensive technology in the renewable-energy sector could seriously undermine increased consumption of renewable energy, especially in the neediest developing countries.

One major technology-policy objective of developing countries is the achievement of technological self-reliance. This objective is not motivated simply by the desire to avoid dependence on imports, but is based on several economic and social considerations. Absorption of technology in a manner that leads to increased self-reliance can also enhance the industrial development of a nation, increase its domestic technological capacities, and create new employment opportunities - all vital development objectives. However, given the different levels of technological development in the nations of the Third World, immediate national self-reliance objectives can differ. In some developing countries, self-reliance may simply imply the acquisition of a local capability, or technological literacy, to choose the best and most appropriate technology available; in some countries, it may mean the enhancement of the industrial capability to absorb imported technology, to produce certain components locally, and to avoid second-generation problems like maintenance, spares, etc.; and in more industrially advanced developing countries, it could mean production of the entire system locally, based on locally generated know-how or well-absorbed imported know-how obtained through technical licences or joint ventures.

In the field of renewable energy, too, many countries would not wish to substitute a new form of energy dependence for their long-standing dependence on oil. However, the current pattern of solar energy industrial and technological development poses real constraints. Technical know-how in the more sophisticated renewable-energy areas is largely controlled by private companies (although often financed at the research stage by government), and industrial products are aggressively marketed. The pious hopes expressed within United Nations agencies and other fora for free exchange of know-how, joint generation of technology, and other such co-operative activities that aim to provide increased access to technical know-how have seldom been realized. Solar energy companies which have technological and engineering capability are only interested in business deals. Self-reliance in the new energy technologies is, therefore, unlikely to be achieved through the free, widespread dissemination of proprietary information from the northern solar energy industries. Nor is self-reliance likely to be spurred by a burst of TCDC (technical co-operation among developing countries). The few developing countries that have set up substantial solar energy research programmes will also try to seek maximum economic and commercial advantages from their hard-earned know-how, especially in the current international climate lacking as it does strong impetus towards technological co-operation within the Third World.

Comparatively few developing countries have substantial indigenous technical research programmes. There are very few research programmes aimed at "depackaging" renewable-energy technologies generated in the industrialized countries and adapting them to local needs and conditions even though such an approach could help to build upon the efforts in the industrialized countries and avoid significant imports of solar energy hardware.

Unfortunately, the sub-critical research and development activities funded by aid programmes, have usually turned out to be only demonstration projects for experimental technologies. They may have helped to generate an appetite for new technology but certainly not the capability to reproduce it. Little ground-work has been laid for future technology transfer against the day when successful demonstrations justify wider utilization.

Every international and bilateral agency has its own unique objectives when it participates in technology-transfer ventures. Some bilateral development assistance agencies exist primarily to promote domestic exports to the Third World, while other organizations are increasingly emphasizing training of Third-World experts and support of Third-World institutions. But, every industrialized country's solar energy technology programme has close links to its national solar energy industry, and most are emphasizing the shorter-term technology and market-development objectives of testing, deploying, and commercializing solar energy technologies. Third-World planning with respect to absorbing this effort tends, not surprisingly, to be left to the developing countries themselves.

Solar energy companies in the industrialized countries also exhibit a variety of strategies in their market development. Some will only export hardware. Others, especially the smaller companies, are willing or even eager to discuss joint ventures or licensing arrangements. Misunderstandings have arisen in certain cases because some companies have not fully understood or shared the objectives of the host countries.

Despite differing objectives among governments, aid agencies, and would-be solar energy exporters, fundamental disagreements over renewable solar energy technology may fortunately be avoidable. Manufacturers and promoters of solar energy technology face the dilemma that the prices of their products cannot significantly decrease without further research advances and a substantial increase in the size of their market, but the market cannot grow until prices fall. If technology transfer were to take place in a manner that would engender local production of renewable energy equipment in Third-World countries, it may help to increase the market, cut costs, and thus provide an opening for further growth in the industry. Many technology producers may welcome such opportunities. Programmes that aim to achieve this technology transfer and help developing countries simultaneously build upon them by improving their own technological capabilities would be of great assistance to developing countries.

One step forward might be for the Conference to emphasize how "technology transfer" can be turned into and associated with "technological co-operation" programmes. Technology transfer has often led to a relationship of dependence. But if commercial joint-venture, or technical-licensing arrangements for the transfer of renewable technologies were carefully supported by technological and financial assistance programmes (by bilateral and international aid agencies) to help recipient countries depackage and adapt the imported systems to local economic and manufacturing conditions, developing countries could better absorb these new technologies and move towards greater self-reliance in this industrial sector. Developing countries themselves will have to consciously take care to develop such research and development programmes.[3]

This approach will require hard decisions by all the actors in the renewable-energy technology-transfer process: by the northern technology manufacturers, by the bilateral and multilateral assistance agencies and by developing-country governments and companies. The assistance agencies have funded few research and development programmes of the nature suggested and these have often been opposed by the industries in the North. However, if the international technology-transfer process in the field of solar energy were to be carefully coupled with technology-development programmes in the developing countries, it would be advantageous to all parties concerned. It would help the northern technology developers to expand their markets at this crucial juncture and it would promote local production in developing countries in a manner that would lead to greater control over the production system by the time a major market for renewable technologies becomes economically feasible. But the two processes must take place together and if they do not, developing countries should carefully consider the consequences of technology-transfer ventures before taking them up in isolation.

Finally, it must be pointed out again that any investment in production or application of renewable-energy systems must be carefully planned and considered in the context of real national and local energy needs and undue fascination with technological systems *per se* should be avoided. But without a concerted effort by the international community, even the necessary renewable-energy technology transfer will experience needless limitations, and without such transfer, the transition to renewable energy sources will be delayed.

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2. Earthscan, IIED's media information unit on global environment issues, produced a briefing document in 1979 entitled, Whose Solar Power? by Anil Agarwal which described research on solar energy in developing countries and the obstacles and opportunities on solar technology transfer of the international solar industry.

3. The International Institute for Environment and Development is currently conducting a study of the opportunities and obstacles to renewable energy technology transfer from the North to the South.

BUILDING NATIONAL CAPACITIES FOR RENEWABLE ENERGY: SCIENCE AND TECHNOLOGY POLICY ISSUES

Fakhruddin A. Daghestani
Deputy Director-General, The Royal Scientific Society
Amman, Jordan

1. Energy Problems and the Role of Renewable Energy

We are confronted today with four major energy problems: the rapid depletion of traditional renewable energy sources; the excessive demand for oil relative to its supply; the difficulty of developing, in the short term, additional conventional and non-conventional energy sources; and the unreasonable imbalance in energy consumption between industrialized and developing countries and between the urban and rural populations in developing countries.

The energy situation for the rural and urban poor, who constitute half of the world population, is alarming. They heavily depend on traditional renewable energy sources such as fuelwood, charcoal, crop and animal residues, and draught-animal power. The demand for fuelwood is increasing and the supply is rapidly being depleted due to deforestation. The current rate of tree planting should increase by at least five-fold to meet the increasing demand that will be taking place during the next twenty years. The input of science and technology in developing and using these resources has been negligible. It is ironic that the people who need energy most employ the least efficient methods of using it.

One of the main reasons for the current energy problems is the price of oil, which had been artificially kept at a very low level from the beginning of this century until the early seventies. This led industrialized countries to shift from coal to oil and to neglect the development of other energy sources. Meanwhile, the massive scientific and technological capacities of these countries were directed to the intensive utilization of oil, using inefficient methods and equipment which ultimately were exported to developing countries. The modern sector of developing countries also followed oil-intensive energy-consumption patterns with the consequence that oil became the source for half of the world's primary energy. As a result, the consumption of oil became excessive and continuously expanding until it was realized in 1973 that the demand ran the risk of outstripping the supply. The fact that oil is depletable and that its price is determined by the equation of demand and supply, as well as by the cost of alternatives, has not been completely acceptable to most industrialized countries that import oil from developing countries. All this has greatly

from developing countries. All this has greatly

diminished the development of other conventional and non-conventional energy sources, including renewable energy. Oil-production rates will level off before the end of this century and the cost of oil will continuously increase in real terms. Within a short time, this will make most renewable-energy applications economical as compared to other alternatives. Developing countries should rapidly build their scientific and technological capacity in renewable energy to reduce dependence on imported oil and to increase the use of their own renewable natural resources.

The difficulties associated with the development of additional conventional and non-conventional energy sources in the short term are immense. However, long-term solutions for developing renewable energy are promising. The World Bank estimates that the world demand for commercial energy will increase by 46% in ten years and that the total investment required for an expanded energy programme in oil-importing developing countries is 350 to 500 billion dollars (in 1980 dollars) over the next twenty years.[1] A large investment in developing non-renewable energy sources will not solve their problem, but will merely postpone it. Furthermore, this will deepen the roots of their present consumption patterns, which are similar to those in industrialized countries. Ultimately, all countries have to rely on appropriate energy mixes, depending heavily on their indigenous resources. Renewable energy resources are abundant in developing countries. Therefore, a reasonable share of investment should be allocated with a view to expanding renewable-energy programmes in developing countries, including those programmes that are designed to strengthen the scientific and technological capacity of developing countries in this field.

Rural and urban poor people constitute 54% of the world population and 71% of the population of developing countries. Yet, their share of energy from traditional renewable sources is only 10% of the world-energy consumption and 20-25% of the energy consumption in developing countries. Their share of commercial energy has been negligible prior to and after the increase in oil prices, and this will remain so far into the future. In 1980, oil-importing developing countries, which constitute 42% of the world's population, consumed 9% of the world's commercial energy. In 1975, the *per capita* primary energy consumption compared to the world average was 18% for developing countries.

553% for U.S.A. (6% of world population), 227% for other industrialized countries, and 97% for countries with centrally planned economies.[2] This great imbalance reflects the international economic disorder and raises not only social and economic issues, but also moral questions. Renewable sources of energy can play a vital role in reducing this great imbalance by contributing large quantities of energy in absolute terms to those who need it most. A stronger scientific and technological base in developing countries can accelerate this process.

2. National Scientific and Technological Capacity for Renewable Energy

Science and technology provide the force for accelerating development by improving the capabilities of a nation to produce. A strong capacity in science and technology is a prerequisite to the planning and fulfilment of national goals aimed at a sustained rate of social, economic, and cultural growth and to the attainment of a greater degree of self-reliance. Economic growth can generally be attributed to two main inputs; the first is the increased quantity of material inputs of capital, land and labour; the second, which is the non-material aspect, is the improved quality of inputs through efficiency.[3] This latter non-material input, which accounts for about 90% of the rate of growth in *per capita* product in western industrialized countries, comes from the national competence and capacity in science and technology. This rate is probably no more than 20% in developing countries. It is the weakness in the scientific and technological capacity that inhibits the social and economic growth of developing countries.

The development of a national scientific and technological capacity in renewable energy will strengthen the ability of developing countries to accelerate their use of this energy source to meet their increasing energy demand. Such a capacity will enable them:

- to develop their national capacity for energy planning, taking into account renewable energy;
- to identify and understand existing renewable-energy technologies;
- to evaluate and select from these technologies those with the potential for local application;
- to modify and adapt these technologies to meet national requirements;
- to generate and develop new renewable-energy technologies that meet specific national requirements;
- to produce systems and products that embody these technologies, and apply them to productive sectors; and
- to operate, maintain and update these systems and products with competitive efficiency.

Establishing such national capacities requires

Establishing such national capacities requires a long-range political commitment by governments and a national will expressed in policies, plans and institutions. The national science and technology policy related to renewable energy should be concerned with many issues related to structure and function, among which are:

- a governmental structure for formulating and executing national renewable-energy plans and programmes;
- research and development institutions and programmes related to renewable energy;
- promotion, co-ordination and finance of research and development activities related to renewable energy;
- the scientific and technological components of renewable energy in the national education system at all levels;
- scientific and technological public services related to renewable energy;
- legal measures, economic incentives and public information needed to enhance the application of renewable-energy technology; and
- bilateral, regional and international co-operation in all fields related to renewable energy.

The national science policy for renewable energy should be viewed as a tool for organizing, strengthening and mobilizing the national scientific and technological potential for the application of renewable energy to aid social and economic development.

Most developing countries do not have explicit short-or long-term science and technology policies or plans, or the appropriate government structures to formulate and execute them as parts of over-all national, social and economic development plans. This greatly limits the role of science and technology in the development of renewable energy sources and in reducing other energy problems that are growing exponentially in these countries. The absence of such policies, plans and structures is most probably due to the fact that decision-makers and planners in many developing countries are still unaware of the role that science and technology can play in development. Furthermore, the instruments needed in these countries for the application of science and technology to the various sectors of the economy and to the economy as a whole are not easily defined or understood.

Effective science and technology policies for the development of renewable energy in developing countries cannot be made in the absence of or in isolation from a general science and technology policy for development. In addition, proper planning for the development of renewable energy cannot be made in the absence of or in isolation from general energy planning that takes all energy sources into consideration.

We shall concentrate in the remaining sections on two major issues: energy planning, and research and development.

3. Building the National Capacity for Renewable-Energy Planning

Energy now ranks equally in importance with the classical factors of production: land, labour and capital. Short-, medium- and long-term planning for renewable energy is indeed complex. This is due to the complexity of energy planning as a whole, which is part of social and economic planning. Energy planning is based on a proper assessment of energy resources and projected needs. The identification of long-term energy needs also requires the ability for long-term social and economic planning. This is further complicated by the lack of detailed knowledge of the role of renewable and other sources of energy in the complex internal and external social and economic development processes. Hence, clear-cut solutions for each country cannot be readily made; extensive research is greatly needed in this area. There are, however, two broad approaches to energy planning.[4] These approaches are very closely linked to the use of renewable energy. The first is the energy-system approach, which affects three activities: increased production of national energy resources, including renewable energy; better and more efficient conversion from one form of energy to another, i.e., from one conventional form to another or to a renewable form; and more efficient conservation of energy, including the development of better end-use devices. This approach assumes that the current role of energy in development remains essentially unchanged. The second approach is through developmental solutions that imply major structural changes in the development strategies, but without affecting the over-all social- and economic-growth rates. Both of these approaches are required: the first is effective in the short- and mid-term; the second is effective in the long-term.

All this indicates the complexity of the technical, social, and economic transformations that will have to be made. Science and technology has to play a vital role in these transformations, in the development of planning abilities and techniques and in implementing the application of renewable energy, regardless of the planning approach which is adopted.

The absence of proper energy plans in many developing countries is mostly due to the absence of appropriate energy institutions and to the shortage of competent energy planners. The development of the capacity for energy assessment and energy planning for all sectors of the economy should take a high priority in the science and technology plan for each country. The development of such a capacity can also be enhanced through regional and international institutions to be established for this purpose.

4. Building the National Research and Development Capacity for Renewable Energy

Technical progress is the result of the application of technical knowledge to production activities. There are two important aspects of technical knowledge as applied to renewable energy: the generation of the needed technical knowledge and its dissemination and utilization. The future role of renewable energy in developing countries is affected far more by the dissemination and utilization of this technical knowledge than by its generation.

The generation of technical knowledge in the field of renewable energy comes mainly from two sources. The first source stems from the normal productive activities of using and producing renewable energy products, systems and services. It provides the base for absorbing and using additional advances in renewable energy. The second source, which is ultimately responsible for continued progress in renewable energy, comes from research and development.

The present research and development systems in many developing countries are not conducive to generating the technical knowledge required for renewable energy or for many other fields. Many developing countries have copied from industrialized countries systems that are not appropriate to their needs.

Major structural changes would be required to develop the national research potential and to use it for renewable energy as well as for other fields. These changes should be guided by factors related to the relevance and to the efficiency of the research and development system. Factors related to relevance include the identification of critical renewable-energy needs to development, the formulation of research priorities and the establishment of policies and mechanisms for the dissemination and utilization of technical knowledge. Factors related to efficiency include government organization of research, research management, qualified manpower, proper research facilities and sufficient financial resources.

The fact that very little research is done in renewable energy by the private sector in most developing countries places heavier responsibilities on government research institutions. This implies a major shift from producing general knowledge to producing the technical knowledge needed for the productive sectors of the economy.

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LOOKING TOWARDS THE FUTURE, BUILDING ON THE PAST: DEVELOPING NEW ENERGY SOURCES

James H. Malinowski
Generation Planning Department
Kermit R. Kubitz
Corporate Planning Department
Pacific Gas and Electric Company
San Francisco, California, USA

1. Introduction

The Pacific Gas and Electric Company (PGE), one of the largest energy utilities in the USA, is also one of the leading utilities in evolving an energy-supply system that responds to the changing world economics of energy. It has done so by building on a long tradition of developing renewable and economical energy resources. It has also developed a sophisticated analytic capability for resource assessment and selection that includes many items not traditionally considered sources of energy by utilities.

At the same time, the PGE faces many of the problems common to other US utilities and, indeed, to those in other countries confronted with a range of future energy options, limitations to the amount of capital available for investment in the energy sector and over-dependence on shrinking supplies of oil. The PGE responses to these problems, its methods of planning and analysis, and its organizational viewpoint may thus be useful to others facing these same problems.

2. Background: The PGE System and its Development

Pacific Gas and Electric Company is, as its name implies, a combination gas and electric company. It supplies gas and electricity to a population of 9.4 million people across most of the northern two-thirds of California (over 243,000 km^2). Its 3.4 million electric customer service points are supplied with power generated by 12 fossil-fuel electric plants, 64 hydroelectric powerhouses and a geothermal complex, the world's largest, of 15 units. In addition, the PGE supplies natural gas to more than 2.8 million customers.

In 1980, the PGE had operating revenues of \$5.26 billion and total assets of \$11.3 billion. It sold \$58.3 billion kWh of electricity and $15,816 \times 10^6$ m^3 of gas to customers. The PGE has 27,500 employees in 13 operating divisions. Its sources of energy in 1980 were as follows:

Electric		Gas	
Natural Gas	42.1%	From California	16.2%
Oil	19.7%	Other states	43.9%
Geothermal	10.4%	Canada	39.9%
Hydroelectric	27.3%		

Its sales of energy, distributed among classes of customers, were as follows:

Electric		Gas	
Residential	33.2%	Presidential	35.1%
Commercial	31.3%	Commercial	27.5%
Industrial	25.4%	Industrial	
Agricultural	6.1%	- Firm	3.9%
Street Lighting	0.7%	- N/Firm	27.3%
Resale	3/3%	Resale	6.5%

PGE's sources of energy and customer base are both, therefore, diverse. California has a strong and growing economy with major sources of revenue from agriculture in the Central Valley and high-technology electronics industries in the San Francisco Bay area. The PGE has an important responsibility, as do all utilities around the globe, to ensure that adequate, reliable supplies of energy are available to meet customer demands for lighting, heating, cooking and refrigeration, communications, and commercial and industrial-business process.

The PGE system developed from the first central generating station in the USA, the California Electric Light Company at 4th and Market Streets in San Francisco. These pioneering electric works were established in 1879, the same year that Thomas Edison invented the incandescent light bulb. From that beginning, the PGE has always been at the forefront of energy technology. In 1895, PGE predecessors were the first to transmit high-voltage commercial power 35 km from the Folsom hydro plant to Sacramento.

Subsequently, the PGE developed the energy of the falling water of the Sierra mountains into the largest privately financed chain of hydroelectric plants in the USA. These developments were not without their mishaps, however. At the initial tests of the San Joaquin No. 1 hydroelectric power plant in the 1890's, the engineer in charge had neglected to fasten the nozzle to direct the flow of water against the Pelton wheel. When the valves controlling the water were opened, a flood roared across the powerhouse floor, and the emergency shutdown of the high-pressure head of water caused the penstock tubes to rupture. Eventually hydroelectric development became the backbone of the PGE energy system, supplemented by fossil-fuel electricity generation after World War II.

By the 1960s it had become obvious to the PGE management that new sources of energy would have to be developed. Although oil-fired generation had been constructed to meet growing demands for service following World War II, excessive dependence on one source of primary fuel was rightly viewed as unreasonable. Therefore, the management, which had been involved in early development of civilian uses of nuclear energy, including obtaining licence Number One for the Vallecitos Nuclear Power Plant, began to seek a site for a major fission generating facility. Consultation with environmental groups led to the siting of the Diablo Canyon Nuclear Power Plant on the California coast, south of San Francisco.

Beginning in the mid 1950s, the PGE began to experiment with the use for commercial electric-power generation in the area of fumaroles and volcanic rock known as The Geysers. At The Geysers, the PGE, working with steam suppliers, developed power plants supplied with natural steam from the earth. Initial power plant sizes were small, starting with units in the tens of megawatts and increasing to 55 and then 110 MW. The PGE now has a capacity of 900 MW at The Geysers, with an additional 300 MW under construction. The total Geysers area potential has been estimated to range from 2100 to 2700 MW.

The cost of power from The Geysers is among the lowest of the sources of baseload power for the PGE at US$0.03-4 per kWh. This is the result of a pricing formula which based the escalation of the price paid for steam on the average cost of PGE thermal generation fuel while setting a base price for such purchases at a level which insured that the cost would always represent a savings for PGE customers compared to the cost of thermal generation.

This pricing formula, with its combination of savings for customers while allowing producers to anticipate and share in the escalation of the value of energy, was an important factor in the successful development of The Geysers. It is an example of the importance of developing fair contracts among participants in energy development, which provide sufficient incentive for producers to proceed with desirable resources technologies while providing economic benefits to users. It is also an illustration of how reasonable and equitable sharing of benefits can minimize controversy, delays created by negotiation, and transaction costs, which can all retard development of an otherwise desirable resource.

Geothermal development is proceeding at The Geysers and elsewhere. Now that the PGE has established a reliable record of energy production at The Geysers, other utilities are also entering the area and developing steam wells and generating facilities. Major barriers to further geothermal development are concerns about the long-term availability of the steam field as more wells are drilled, site selection in the area of faulting and slope instability associated with the volcanic origins of The Geysers area, and mitigation of the environmental impacts of steam production. These impacts are principally associated with the emission of hydrogen sulfide (H_2S) into the atmosphere.

In addition to the dry steam at The Geysers, California contains substantial amounts of hot-water geothermal resources. These hot liquids may "flash" into steam under the reduced pressure of being brought to the surface. Most hot-water geothermal development is taking place in the Imperial Valley.

Flashed-steam generation is the most common form of geothermal development around the world. The San Diego Gas and Electric Company plans to purchase electricity from the Cerro Prieto plant in Mexico where 150 MW of flash generation exist with expansion to 800 MW planned in the future. Japan has 170 MW of flash steam, developed since 1924, and other plants of this type are located in Ireland, Italy, New Zealand and the Philippines. If further field development at The Geysers indicates a transition from dry-steam to hot-water resources, flash processes may be developed there. The PGE is also considering developing other hot-water geothermal resources in or near its service area if those resources can be proven to be adequate to support commercial plants.

The hydroelectric resources of the PGE are still being developed as rapidly as possible. Certification of new power plants usually follows an application to a state regulatory agency, preparation of an environmental impact report and public hearings which consider the need for power, plant design and safety and means of reducing or eliminating major adverse environmental impacts. These hearings assure that future power-plant development is economical and consistent with public concerns about the area in which the plant will be developed.

As the price of oil increases, the PGE continually reviews the economics of potential resources. These reviews often indicate that, under the latest economic conditions, it is desirable to update or rebuild a power plant or develop a new project previously considered uneconomical. These include PGE hydroelectric power plants as small as 0.5 MW now under consideration.

In addition, the PGE is developing a major pump-storage facility, the 1120-MW Helms Creek project. Pumped storage is the hydroelectric form of a battery, with water pumped uphill during the low-load periods in the evening and used to generate power during peak-load periods. The Helms Creek project is environmentally favourable because it uses two existing reservoirs with most construction work taking place far underground. The powerhouse will be more than 305 m below the surface. Three big reversible pump-turbine units produced in Japan will be located in a chamber 25 m wide, 102 m long, and 44 m high carved out of solid granite. A penstock almost 914 m long in the rock will supply water to the pump-turbines at 280 m^3 per second. The pump-storage unit, with its ability to produce power when needed in a matter of seconds, will be a useful complement to the future PGE electric system. Its flexibility will mean added resilience for the bulk power-supply system in conjunction with future intermittent energy sources requiring storage for continuous service, such as wind and solar energy or some cogeneration facilities.

3. Looking Towards the Future

The present development of the PGE system provides both the technical and economic basis for future resources. As the price of energy has risen, driven by higher primary-fuel prices for oil and natural gas, the PGE has searched for alternatives to the continued burning of oil. Rising energy prices and customer resistance to the rate of escalation of these prices have reduced PGE ability to raise the vast amounts of capital necessary for large numbers of new central generation projects. While some oil-displacing projects will be needed, most oil displacement in the next decade will come from the operation of the already-completed Diablo Canyon Nuclear Power Plant and a wide variety of energy resources under development such as conservation, wind, biomass, cogeneration, solar energy and advanced geothermal systems.

Conservation

Conservation has already made a major contribution to meeting the present and future energy needs of PGE customers. According to the latest PGE long-term plan, conservation has halved the rate of growth of energy demand to below 2% per annum. By 1990, it is estimated that conservation will reduce the peak load by as much as 5,000 MW below what it otherwise would have been. The effects of conservation have been reflected in a reduction of long-range resource plans for both natural gas and electricity. As a result of lower forecasts and capital constraints, the PGE in 1980 deferred three electric projects - a combined-cycle unit in San Francisco and coal-fired plants in California, Nevada and Utah. Conservation is not only available, it is often inexpensive, quick, and less capital-intensive than other energy-supply options.

Conservation is an economically rational response to the changed economics of world-energy supply. Some authorities believe that the major impact of the OPEC price increases on US consumers has now been completed. The process of reallocation of capital and fuel sources to reflect these prices means that the total real costs for energy related services will not rise and may decline in the future. That is, the combination of more efficient energy appliances, price-induced demand reductions, and new energy resources stimulated by the present level of world oil prices means that substitutes for oil can be developed faster and more economically than the price of oil can be raised in the future. If so, this is good news for the energy-consuming world.

In order to discuss how the PGE evaluates conservation and renewable and alternative resource opportunities, we must introduce concepts: supply curves and marginal costs.

Supply curves are hierarchies of conservation opportunities that describe the costs of conserved or produced energy that are potentially available. Beginning generally with low or no-cost measures and gradually increasing with more complex and costly measures, such analysis provides a means of prioritizing conservation opportunities in order to get the best bargains first. In an investigation before the California Public Utilities Commission, the PGE presented a witness, Dr. Stephen Feldman of the University of Pennsylvania, who ranked conservation cost-effectiveness as follows:

(a) energy conservation in buildings, primarily in the form of insulation, weatherization, weather stripping and caulking, and all measures to control heat loss or air infiltration;

(b) passive solar applications, including such things as fenestration, size and location of fenestration, thermal mass, overhang, shading, and orientation;

(c) solar water heating; and

(d) solar space conditioning.

The PGE, in connection with its conservation programmes, has presented quantitative analyses of the societal cost of various conservation measures as follows:

Single Family Residence
Societal Cost-effectiveness
(in thousandths of US$/kWh)

Conservation Measures	Contracted	Do-it yourself
Caulking	6.6	3.0
Weatherization	32.8	11.7
Low flow showerhead	32.6	13.7
Water heater blankets	16.9	14.9
Storm doors and windows	71.7	40.7
Floor insulation	139.9	50.8
Clock thermostat	71.7	-
Wall insulation	77.6	-
Lighting conversion	447.1	221.2
Duct wrap	567.4	385.6

These costs of conserved energy from an implicit conservation supply curve are then compared with the costs which society would otherwise pay. Because the alternative to conservation is consumption of produced electric energy and electric utilities dispatch production facilities in rank order of economically efficient production, the alternative cost is that of the utility's marginal generation source. Thus, the term marginal costs, which refers to the unit or type of generation which would be the basis for the cost of generating incremental kilowatt-hours. To be theoretically precise, the value for purposes of comparison with conservation may be the decremental marginal cost, or cost which can be foregone if demand is reduced. Thus, the term avoided costs is often used interchangeably with marginal costs in evaluation of resource and conservation options.

For 1981, the initial year marginal costs of PGE including both energy and capacity are US$0.0923/kWh. This meant that most of the measures analysed were cost-effective, although in some cases, the costs of contractor-installed measures were not good investments for society. Do-it-yourself installations, which are encouraged by the PGE may be considerably more cost-effective.

Similar analyses have been prepared for solar water-heating systems in northern California and, based on systems costing about $3000 for a family of four, indicate a societal cost of conserved energy in the range of US$0.08-0.085/kWh. Thus, solar water heating is, on a theoretical engineering economics basis, cost-effective when compared with marginal cost electricity. Unfortunately, solar-energy systems require significant amounts of materials which are also subject to price inflation. Some systems are currently being sold at prices in excess of $3600, which may make solar energy marginally economic unless performance is better than anticipated.

Another consideration that must be weighed in selecting resource options, including conservation or alternative energy systems, is capital intensity. Analysis of the relative investment requirements per unit of energy produced has led Dr. Edward Kahn of the Lawrence Berkeley Laboratory to conclude that while conventional energy generation facilities and residential conservation measures are about equal, solar energy systems are two times as capital intensive. A similar conclusion was reached by Dr. Sam V. Shelton of the Georgia Institute of Technology who presented a ranking of conservation options by capital investment per barrel of oil saved to the California Commission. (Table 1)

As shown by this table, in a capital limited situation, weatherization measures provide the most effective investment allocation if oil reduction is the goal. As a result, the PGE has proposed to finance customer investments in conservation at zero interest. The Zero Interest Plan (ZIP) for conservation financing was compared by the Los Angeles Times to the discovery of gold in California.

Table 1

Measures ranked by capital investment	Capital cost per barrel saved/y
Solar water heater replacing oil or gas heater	$905
Wall insulation (0 to R-11)	$435
Solar water heater replacing electric heater	$405
Heat pump space heater with electric heater	$251
Wall insulation (0 to R-11) replacing electric heater	$251
Storm window with oil or gas heater	$190
Ceiling insulation (R-9 to R-19) with oil or gas heater	$174
Water heating heat pump	$105
Storm windows with electric heat	$102
Ceiling insulation (R-9 to R-19) with electric heater	$76

Cogeneration

The PGE has an active cogeneration programme. This includes the development of facilities fueled by urban, agricultural and timber wastes, frequently called biomass generation.

The principal means for encouragement of these dispersed, customer-developed sources of electric supply is the standing offer to purchase the output at the PGE avoided costs. As of the second quarter of 1981, the PGE offer for cogenerated electricity or other qualifying technologies was in excess of US$0.685/kWh for energy alone. If firm capacity is available, the purchase price can be even higher.

The PGE has owned 179 MW of cogeneration since the early 1940s and had, as of the end of 1980, entered onto contracts or other commitments to acquire the output of 14 such projects with a total capacity of about 200 MW. The California Public Utilities Commission has estimated the total cogeneration potential in the PGE service territory at about 2500 MW by 1990. Whether this much cogeneration development will take place is dependent on two economic factors, in addition to environmental and fuel availability restrictions.

The first economic barrier is the high rate of return which a recent survey conducted for the PGE indicates is required by unregulated businesses considering cogeneration investments. The range of required internal rate of return for cogeneration projects being considered by businesses other than utilities was indicated to be from 15 to 40%.

If cogeneration projects do not meet these high financial return requirements, then the second question is whether utility regulation of the PGE will provide the Company with the financial strength to make these kinds of investments. In recent years, the PGE has only earned about 11 1/2% on its shareholder's investment, well below both the 14.1% found fair and reasonable by the Public Utilities Commission and the rates of return required by unregulated businesses for energy projects.

Photovoltaic

The PGE believes photovoltaic generation has longer range potential to supply economic energy throughout its service area. Many parts of the PGE system receive relatively high levels of solar insolation and those insolation patterns provide a good match to the area load patterns which tend to peak in the afternoon on hot summer days.

The PGE photovoltaic development programme includes the testing of a broad range of commercially available photovoltaic elements and a contract with Westinghouse Corporation to help finance a silicon dendritic-web photovoltaic pilot plant production facility in return for the right to purchase 30% of the output of a commercial scale facility planned by Westinghouse. The PGE plans to install its share of the initial output of these facilities at various locations in its service area. If the programme is successful in producing economic photovoltaic cells, as much as 100 MW of photovoltaic capacity could be installed by 1990.

Solar Thermal

The PGE is following developments in solar-thermal power generation with great interest. Exxon Corporation and the PGE have submitted a joining proposal to the US Department of Energy to develop a solar thermal cogeneration facility design to be used in the Kern County oil fields to produce steam for secondary oil-recovery operations. The PGE is also considering participation in the development of commercial-scale solar thermal power plants.

Wind

The PGE considers wind generation to be the most promising emerging solar energy technology for economic commercial application in its service area. Several years ago, the Company committed itself to a major wind-energy development programme. That programme includes a major wind monitoring programme on two wind-farm sites located in coastal passes near San Francisco and the installation of a 2.5-MW Boeing MOD-2 wind turbine generator (WTG) at one of those sites in the Spring of 1982. As a result of this programme and various state and federal government tax credit programmes, substantial interest has developed by third parties who propose to build wind-generation facilities on these wind-farm sites.

The PGE recently signed one contract and is in the final stages of negotiation with another entrepreneurial wind-farm developer. Together, these two projects constitute about 380 MW of installed wind capacity expected to be developed in northern California in the next decade. One of these installations would be the world's largest wind-powered electricity generation complex, some 350 MW by 1989. This complex would be built on property near Fairfield, California, which the PGE acquired for developing wind-powered generation. Other proposals are being discussed which could substantially increase this total if the technology meets performance targets.

It is expected that with the sizeable commitments now being made in several areas of the US, wind energy permit mass production of WTGs to take place with corresponding reductions in unit cost. On the other hand, there will undoubtedly be setbacks along the way to a mature wind-generating technology. One of those setbacks occurred when an innovative design, a vertical axis WTG, being tested for delivery to the Southern California Edison Company, collapsed recently. But just as such isolated incidents in the development of hydroelectricity did not halt long-term progress in an economic resource, wind technology undoubtedly will continue to develop and the PGE will continue to be in the forefront of this and other renewable technologies.

4. Summary

The PGE is committed to the economically efficient, environmentally sound development of energy-production technologies to meet the needs of its customers and contribute to national energy policy goals. It has carried out this commitment by seeking energy from conservation sources, geothermal energy, cogeneration and the developing technologies of wind and solar generation. Its process of resource selection and development is rationalized by using the common yardstick of marginal costs for comparison of both conservation and production sources. The future looks promising for both the PGE and the new and renewable energy technologies which are being developed with the PGE assistance and encouragement.

ENERGY, FOOD, ECODEVELOPMENT

Ignacy Sachs
Ecole des Hautes Etudes en Sciences Sociales, Paris, France

The Nairobi UN Conference on New and Renewable Energy Sources will, inter alia, focus on the energy biomass potential within the context of an orderly and sustainable transition towards the post-oil world. It will also address itself to the so-called "second energy crisis": the condition of hundreds of millions of people in the Third World who cannot afford to buy commercial energy even to meet their minimum cooking needs due to the soaring real cost of energy. These people find it increasingly difficult to find firewood and/or its substitutes. In order to survive, they indulge in predatory deforestation, causing environmental disruption and, in some cases, adverse climatic changes. The need to bring under cultivation additional available land, even if it is not well suited for agriculture, acts in the same direction.

No doubt, given the rise of real energy prices, biomass energy holds considerable promise, if properly managed. An array of technologies of different degree of sophistication, capital intensity and scale of production is already available. However, sound ecological principles are required to ensure the sustainability of a considerably increased production. No resource is renewable where the conditions of its renewability are not respected: a felled forest where reafforestation is not undertaken is but a mine of timber and/or fuelwood. Stepping up biomass energy production with no regard to its immediate and long term, local and distant, environmental impacts might bring about an ecological crisis.

The social consequences at stake are also very high indeed. Poor people all over the world badly need more energy, but rich people can afford to pay more for it, so that biomass energy may end up fueling private cars rather than helping to cook the dinners of the poor. Moreover, in a situation of scarcity of good agricultural land, competition may occur between production of food and biomass energy, adding a new dimension to the traditional conflict between production of food for subsistence, on the one hand and industrial crops and agricultural commodities for exports on the other.

Again the chances are that the car owners will prove stronger than the owners of empty stomachs. An additional complication may arise if real prices of energy continue to mount: biomass energy prices may push up the cost of food over and above its increase due to higher prices of agricultural inputs, adding dramatically to the plight of the urban poor, while intensifying the pressures for the concentration of land at the expenses of small land owners. The chances of competition between food and biomass energy for land, but also capital and other scarce resources, will be greatly enhanced by the juxtaposition of single-purpose agricultural projects evaluated on a micro-economic basis with little or no consideration for the externalized social and ecological costs.

These fears should not distract us from seeing the importance of biomass energy both in Third-World and industrialized countries. The more so that biomass energy has a far greater employment potential than any other form of energy production. But they force us to spell out and consider carefully the food-energy nexus in all its complexity and at the same time to build into all the projects the condition of sustainability.

Under these circumstances, it is submitted that food and energy production should be considered jointly on an ecosystem-specific basis. We ought to develop food and energy "co-production systems" based on a careful analysis of the biomass potential of each ecosystem. As a matter of fact, such an analysis should be also culture specific and, in order to become operational, even site specific. The best way of resolving the conflict over land, capital and skills between food and energy production is to deal with it ex ante.

We are thus referred to the ecodevelopment approach. The aim is to look for socially desirable, economically viable and ecologically prudent man-made production systems, paradigmatically inspired by the concept of ecosystem, and capable of jointly supplying food for people, animal feed and biomass energy. Environment appears in this perspective as a resource potential to be harnessed on a sustainable basis and, as much as possible, in an ecologically benign manner. The design of such "co-production systems" implies on the one hand comprehensive land-use planning and, on the other, a careful consideration of the ecological complementarities between different activities, with special emphasis on the use of forest, agricultural and human wastes.

Transforming waste into resources proves in many cases the best way of dealing with environmental disruption. All the social implications of the proposed co-production systems must be equally spelled out. The advantage of co-production systems over juxtaposed monocultures could well reside in their greater ability to use in a fuller and more equitable manner the available working force. The choice of an appropriate technology mix is, of course, of paramount importance here.

An enormous task faces us: opening a fruitful area for South-South inter-regional co-operation. The Nairobi Conference could provide the necessary initial momentum to launch this co-operation.

V. OVERCOMING BARRIERS TO IMPLEMENTING NATIONAL RENEWABLE ENERGY PROGRAMMES

THE CASE OF INDIA

M. S. Swaminathan
Member, Planning Commission, New Delhi, India

1. Delineation of the Parameters of the Problem

There is a growing interest in developing decentralized systems of integrated energy supply based on a feasible blend of renewable and non-renewable forms of energy. In developing countries non-commercial forms of energy such as fuelwood and plant, animal and human residues still constitute a significant proportion of the total energy consumed in rural areas. The purposes for which energy is needed can be classified broadly into (a) domestic, (b) agricultural, (c) industrial and (d) organization of services such as lighting, pumping water, transport, haulage, etc. National renewable energy programmes will have to first aim at a clear delineation of the role renewable forms of energy can play in meeting the needs of each one of these sectors.

2. Identification of Possibilities

The forms of renewable energy which can be economically tapped in each agro-ecological area will have to be carefully identified. These can be broadly grouped under the following categories:

(a) Energy of photosynthetic origin, including fuelwood and biomass;

(b) Energy from refuse and wastes, including biogas from animal and plant refuse and sewage and garbage from towns and cities;

(c) Solar energy used in ways other than photosynthesis, such as photothermal and photovoltaic applications;

(d) Hydro, wind, tidal, geothermal and other sources available in a specific area; and

(e) Direct use of animal and human energy.

A detailed study of the potential for harnessing these sources will help in the formulation of a location-specific action plan.

3. Constraints Analysis

Once the potential for harnessing different forms of renewable energy sources has been assessed and established in a scientific manner, there is a need for identifying the constraints responsible for the gap between potential and actual application. Quite often social-engineering aspects may be even more important than gaps in technology in bridging the gap between potential and actual use of renewable energy in an area. Hence, social scientists should also be included in the multidisciplinary team which should be constituted for carrying out the constraints analysis. The aim of the constraints analysis should be the identification of the precise factors which need attention in each country for promoting a dynamic programme of renewable-energy utilization. The constraints could be broadly classified under:

(a) economic viability of the package of technology recommended;

(b) social acceptability;

(c) adequacy of the package of services, including delivery and utilization systems; and

(d) public policies.

The system will succeed only when an economically viable and socially acceptable technological package is supported by appropriate package of services and public policies.

4. Removal of Constraints

While gaps in technology can be identified and removed relatively easily, action on the findings of the social-impact analysis will be more difficult unless those in charge of public policy take the requisite remedial steps. For example, the spread of individually owned biogas plants may make it more difficult for landless labour families owning no animals to meet their domestic energy needs. Women in such families may meet part of their energy needs by collecting animal refuse from streets and community land. If this source is cut off, they will be forced to cut trees for fuelwood. Hence, even before a massive programme of biogas-plant popularization is undertaken, arrangements will have to be made for meeting the fuel needs of the poor. The supply of fuel will have to be made a part of the basic human-needs programme of every government.

In the case of community-owned biogas plants, it will be necessary to involve the community in deciding the purposes for which the energy should be used. Some rural communities may want to use the energy for lighting, while others may like to use it for pumping water for a drinking-water supply. The system should respond to the needs of the community, so that the community has a stake in its maintenance. Similarly, energy plantations will be successful only if the rural community has a full sense of involvement, not only in planting trees but, more importantly, in tree proteciton. If the trees chosen can supply fodder and feed, in addition to fuel, the rural community will feel even more interested. By choosing leguminous shrubs and trees, biological nitrogen fixation can also be promoted. A common denominator of enlightened self-interest can alone generate the needed extent of community involvement.

In most developing countries, the harnessing and management of renewable energy sources have been traditionally in the hands of women. However, most extension and training agencies tend to bypass women when scientific programmes for renewable-energy use are launched. This will not only undermine the success of such programmes but also cause great hardship to women by displacing them from their traditional occupations. Hence, a high priority should be accorded to training and involving rural women in renewable-energy projects.

5. Energy Impact Analysis as an Integral Part of Formulation of Development Programmes

The energy impact statement relating to each development project should spell out the potential role of renewable energy sources in meeting the energy needs of the programme. For example, by linking a decentralized system for rural food-grain storage with urban distribution outlets, much of the energy needed for transport can be met by the use of available forms of animal energy. Such an outlook should be fostered at all levels of policy and programme formulation. It will be necessary for this purpose to hold seminars for policy makers based on appropriate case studies.

6. Public Participation and Institutional Mechanisms

A suitable institutional mechanism will have to be developed in each country for promoting public participation in renewable-energy programmes. These programmes will need for their success an appropriate blend of the principles underlining "production by the masses" and "mass production". Decentralized production with appropriate centralized back-up services and delivery systems may be necessary.

An effective method of ensuring the success of renewable-energy programmes is the organization of Renewable-Energy Associations in each area. These should be associations involving all the families living in a compact area. Such associations helped by technical training and extension support could foster the harnessing and effective utilization of all available forms of renewable energy. They can also run "Waste Exchanges" where all community and individual wastes can be gathered and recycled. Such associations can also monitor the social impact of programmes and help in initiating timely "mid-course corrections" in the programme, in case of any adverse social repercussions.

We need a fusion of political will, professional skill and popular action for promoting the increased harvest of renewable energy sources and their use in integrated energy supply systems in different countries. The movement should grow from the villages and this is why I consider that Renewable Energy Associations organized by the people of each area can trigger a self-propelling movement in this field. Universities and technical institutions can serve as catalysts in getting such local-level Associations organized. Not only will this help to promote relevant location-specific action, but it will also stimulate a greater degree of awareness of both potential and problems. Given such an approach, small government-sponsored programmes in renewable energy use can assume the dimensions of a mass movement. Above all, such Associations can help to promote the harvest of solar energy through the photosynthetic pathway by getting trees planted in every piece of vacant land. This will be the real "Green Revolution".

THE CASE OF BRAZIL

José Goldemberg
Instituto de Física, Universidade de São Paulo
São Paulo, Brazil

To understand the existing barriers to the implementation of renewable-energy programmes and how to overcome them, it is necessary to give fossil fuels (non-renewable energy sources) their due credit. Fossil fuels, and among them petroleum and its derivatives, are extremely convenient and attractive energy sources.

This can be seen in the Table, which shows the energy densities of various renewable energy sources. For example, one can show from the data in this table that one liter of petroleum has an energy content equivalent to all the solar energy incident on a 10-m^2 surface during a full day. Also, petroleum is a liquid and can be easily transported and fed into internal-combustion engines.

Due to these attractive characteristics, an elaborate industrial and economic system was built on the use of fossil fuels, and the "modern sector" of most countries around the world is now based on this system.

Undoubtedly this system would continue to prosper if natural oil resources were greater than they are and if a host of other problems was not to plague the system, mainly in the last decade. Some of these problems are intimately associated with the organization of OPEC and others are related to the security of supply and environmental factors.

It would be naive to assume that renewable energy sources have been receiving increased attention just because of their intrinsic virtues. Although these virtues are becoming obvious in a number of instances, old habits and well entrenched interests are very resilient to change and renewable energy sources face an uphill battle to be adopted around the world.

It is a widespread misconception to think that renewable energy sources can only be meaningful in rural or isolated communities. In reality, most national projects which have been successful, such as the Alcohol Programme in Brazil, combine the intrinsic low-density nature of renewable sources with a "centralized" approach in which large tracts of land are used to collect and convert solar energy into biomass which is then processed in large distilleries to produce alcohol, which is used as a modern high-density fuel. This procedure should dispel the common-sense idea that biomass is an archaic and under-developed type of energy.

Actually, high technology plays a big role in converting low-density renewable resources into concentrated forms which fit in well with the needs of urbanized centres.

In the case of minihydro-electric stations, one has to realize that many of them are not so small and that their successful utilization has to do with gains which result from the use of standardized equipment; engineering costs which are very high (25% in big hydro-stations), because of their "custom made" character, can be cut drastically in minihydro-stations to approximately 10%.

Table: Energy Densities for Renewable Energy Sources

Source	Watts/m^2
Fuelwood (planted forests)	0.3 - 0.8
Biogas	0.1
Hydropower	0.1 - 0.5
Wind	1 - 4
Ethanol from sugarcane	0.2 - 0.4
Solar direct (heat)	60 - 150
Solar direct (electricity)	6 - 30

We will discuss in succession a few of the barriers to the implementation of national renewable-energy programmes in order to gain some understanding on how to overcome them. Since one of the largest of such programmes is being rapidly implemented in Brazil, and will replace half of the gasoline used in the country in 1985 by alcohol produced from sugar cane, this country is a particularly interesting one to study. Most of our remarks are also relevant to other developing countries.

A basic problem with renewable energy sources is that they sometimes require changes in the consumption habits of people. The success of a "petroleum-based civilization", as exemplified so vividly by the United States and the "American way of life" (which has rapidly spread to Europe), has created a powerful goal which all developing countries are trying to reach. Three quarters of the world are a part of the so-called Third World population and pressures to gain wealth and "progress" are very strong. In most of this population, people have succeeded in establishing an island of wealth in a "sea of poverty". On the "islands" live a small fraction of the population, typically 10 - 20%, in an urban environment and copying quite closely the consumption patterns of cities in Europe and the United States. The "elite" living on the "island" run the country in a precarious political balance which requires strong government, in many cases, to keep things as they are. These elite groups have no motivation for political and economic, and therefore technological, change which are required by the new energy sources.

Necessity is, however, a great teacher. The desire to maintain the system has encountered two basic difficulties in developing countries: the rising cost of petroleum, which disrupted external trade balances, and security of supply. Great attention must be given, therefore, to indigenous resources: the very obvious resources in most developing countries, since they are all located in the equatorial and warmer regions of the earth, is the sun.

In the case of Brazil, the ambitious Alcohol Programme was launched when it became obvious that the automobile industry would have to be partially diactivated if a substitute for gasoline was not found. In addition, sugar, in the tight international market, had been experiencing rapidly fluctuating prices. Both these factors created a situation making it economically reasonable to convert part of Brazil's sugar into alcohol. Since the technology was available, the Government decided to subsidize the production of alcohol as a method of increasing the security of supply of liquid fuels. The cost of a barrel of alcohol (corrected for its lower calorific content) is US$50 which is higher than petroleum, at US$35/ barrel, but not unduly so. As the price of oil continually increases, the Programme will reach the break-even point without any subsidies. The interest of national industries in producing the equipment for the alcohol distilleries has also played in favour of the Programme.

Significatively, the national petroleum company of Brazil - PETROBRAS - viewed the Alcohol Programme as a threat and kept out of it.

What was witnessed here was a classical case of realignment of economic interests spurred by Government incentives. The role of independent energy analysts was to point out the attractive aspects of a renewable energy programme and to convince Government and private industry that all would benefit from it; in addition to that they gave credibility to the technology involved (the use of alcohol in present-day motors) which was challenged by the prevailing interests.

These ingredients seem to be essential for the implementation of other national programmes. There are three other programmes presently being discussed in Brazil which have a good chance of being successful: mini-hydro stations, vegetable oils as a replacement for diesel oil, and flat-plate solar collectors for the production of hot water. For all of these programmes, technologies exist and are available. The only problem seems to be the realignment of the interests of a number of groups.

In the case of mini-hydro stations, there seems to be a lack of interest on the part of electric utilities and enterpreneurs who are prospering from the construction of large hydro-stations for which it is easy to obtain financing from national and international banks. The number of companies involved in these activities is, generally speaking, very small. On the other hand, the building and operation of many small hydro-electric generating plants will require a decentralization of those activities which are now in the hands of a number of municipalities and local enterpreneurs.

In the case of flat-plate solar collectors, the situation is even more advanced since there are a large number of manufacturers and the only remaining barrier is the non-existance of easy lines of credit in commercial banks for this type of equipment. It is true that until recently the price of fuel oil and liquefied natural gas was very low because of Government subsidies which made the return time for the investment in solar collectors high; these renewable energy sources were in a way being "negatively subsidized" i.e. "punished" by the Government subsidies to fossil fuels. The removal of these subsidies has been enough to make them more attractive.

In the case of vegetable oils, Brazil is trying to repeat the success of the Alcohol Programme by growing oil-seed species such as soy beans, oil palm and others that are edible, but could also be processed to run diesel motors. Again, here the technology is available but there is the need for initial encouragement by the Government; since diesel oil is subsidized, the costs of vegetable oils are slightly higher than the break-even point required to make them attractive.

The general feature of these programme is that they have to face existing structures which are geared to satisfy the needs of the great urban centres: big hydro-electric plants, large refineries and a strong automobile industry. These structures take good care of themselves, such as by selling cars on easy long-term loans (which are unavailable for anything else).

Small pushes and reorganizations can lead to very successful renewable-energy programmes without basic changes in the economic structure of the country and certainly without questioning the system as a whole.

As is well known, all throughout the Third World the presence of the State is rather strong in the economy and to speak of a free-market economy in most of them is unrealistic.

What has to be done, therefore, to implement national renewable-energy programmes is to reorient public investments in particular directions. This is not a novelty since public investments are used all the time to provide advantage to specific interests; there would be nothing unusual in orienting them to give a slight push to renewable energy sources.

Once this has been done, the new system of private interests will be able to take care of itself, as illustrated by the Alcohol Programme which is being subsidized less and less all the time, and will ultimately subsist without any subsidies.

National development banks, regional development banks (such as the Inter-American Development Bank) and the World Bank should develop new attitudes towards those renewable energy sources which are at the brink of becoming economically viable. There is no longer any need for a philosophical attitude favourable to renewable sources. They are becoming competitive and a new system of alliances and social forces, inside the capitalistic system, seems quite capable of pushing them ahead.

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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Abstracts of Selected Solar Energy Technology

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太阳能 SOLAR ENERGY СОЛНЕЧНАЯ ЭНЕРГИЯ सौर ऊर्जा ENERGÍA SOLAR সৌর শক্তি
SONNENENERGIE ENERGIA SOLAR الطاقة الشمسية 太陽エネルギー ENERGI MATAHARI
ÉNERGIE SOLAIRE सूर्य शक्ति ENERGIA SOLARE شمسی توانائی DAYANING SURYA 태양에너지
ஞாயிற்றியலான ஆற்றல் సూర్య శక్తి دھوپ دی طاقت GÜNEŞ ENERJİSİ СОНЯЧНА ЕНЕРГІЯ
NĂNG LƯỢNG MẶT TRỜI ENERGIA SŁONECZNA સૂર્ય શક્તિ СОЛАРНА ЕНЕРГИЈА ಸೂರ್ಯ ಶಕ್ತಿ
انرژی خورشیدی സൂര്യോർജ്ജം KARFIN HASKEN RANA ସୂର୍ଯ୍ୟ ଶକ୍ତି NISHATI YA JUA နေစွမ်းအင်
พลังงานแสงอาทิตย์ ENERHIYA NG ARAW ENERGIE SOLARĂ SOLENERGI ZONNE ENERGIE
ਸੂਰਜ ਦੀ ਸ਼ਕਤੀ دلمر انرژی SLUNEČNÍ ENERGIE ÉNESI PANON POÉ قوتِ سورج NAPENERGIA
TENAGA SURIA AGBARA ŌRUN SEMBE DIGA NAANGE IKE ANYANWU ພະລັງ ຈາກ ແສງອາທິດ
AMANDLA ELANGA සූර්ය රශ්මි බලය ҚУЁН ЭНЕРГИЯСИ گئون انرژیسی ΗΛΕΙΑΚΗ ΕΝΕΡΓΕΙΑ
ENERHIYA SA ADLAW سج جي قوتُ የፀሐይ ፡ ኀይል СЛЪНЧЕВА ЕНЕРГИЯ SUNČANA ENERGIJA
ENÈGI SOLÈY ሁ·ምና ፡ እዱ ថាមពល ព្រះអាទិត្យ KOWADDA PANASSA AREH HERIN'NY MASOANDRO
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MATLA A LETSATSI CUARAJHY MBARETÉ KATAN U JANTE BI

UNU THE UNITED NATIONS UNIVERSITY

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Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

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Bombay House, 24 Homi Mody Street, Bombay 400 023, India

Technical Information Center (DOE), P.O. Box 62
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Recipients are encouraged to provide **ASSET** with copies of their publications concerning the technological and socio-economic aspects of solar, bioconversion and wind energy utilization for abstracting in future issues.

THE UNITED NATIONS UNIVERSITY
Printed in Japan 1981

INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following caregories:

A. General

B. Solar Energy
  - B1 Radiation Measurement
  - B2 Photovoltaic Conversion
  - B3 Active Thermal Systems
  - B4 Passive Thermal Systems

C. Bioconversion Energy
  - C1 Biomass Production and Conversion
  - C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Scientists and engineers in developing countries who wish to participate in this information network and receive ASSET regularly may do so free of charge. ASSET is available in industrialized nations at an annual subscription rate of US$25 by sea mail and US$40 by air mail payable by cheque, money order, bank draft or UNESCO book coupons to the United Nations University. ASSET has published lists of the names and addresses of all members of the network as of 1 December 1980 in vol. 1, no. 12 (1979) and vol. 2, no. 10 (1980).

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

416/81 ENERGY OPTIONS FOR THE THIRD WORLD. A.K.N. Reddy (Indian Institute of Science, Bangalore 560012 (India)). P. 6-18 of Southern Perspectives on the Rural Energy Crisis. Nautilus of America, Bolinas, CA, USA (1981). US$4.00 for full publication.

This article begins with an examination of the magnitude and structure of energy targets for the Third World. The growth option, involving the continuous striving to increase GNP, per-capita energy consumption and industrialization, is seen as part of a mentality that resulted in the development of dual societies in the Third World. Emphasis is placed on the development option which focuses on the satisfaction of basic human needs in order to achieve a reduction of inequalities between and within countries, endogenous self-reliance through social participation and control, and harmony with the environment. The energy needs of villages and ways to meet them constitute the bulk of the article. 4 refs.

417/81 PROJECTED INTEGRATED FARM IN NEPAL. K. Dhital. Biogas Newsletter Nepal, no. 11, p. 4-5 (1980).

This article describes a proposed integrated crop-livestock agro-processing complex to be based at Janakpur, Nepal. This project was proposed by the Agricultural Development Bank and is a small effort towards creating a self-sufficient rural community similar to one reported in China. The plan of the farm aims to achieve the integration of several agricultural, aquacultural, solar energy and biogas energy components with complete recycling of waste. These include biogas plants with associated slurry and storage tanks for operating a 3-kW generator, a 3.7-kW pump, providing domestic cooking, as well as energy to operate a fruit-processing plant. Energy for water heating, crop drying and refrigeration will be supplied by solar energy. Fish, livestock, fruits and vegetables will be produced by the farm.

418/81 NEW VILLAGE USES OF RENEWABLE ENERGY SOURCES. J.W. Howe (Overseas Development Council, Washington, DC (USA)). P. 93-108 of Energy and Environment in East Africa (Proceedings of the International Workshop on Energy and Environment in East Africa, held in Nairobi, Kenya, 7-10 May 1979). ERS-3-80 (March 1980). United Nations Environment Programme, Nairobi, Kenya (1980).

The goal of improving the physical quality of life is dependent upon finding substitutes for human energy at the village level. No prospects of meeting such a large energy requirement from conventional sources such as petroleum, nuclear, coal or major hydro are seen. In some instances (e.g., Zaire or India) there may be enough hydro-electricity or coal, but the problems of distributing the power to the distant countryside have proven to be overwhelming. Three factors make solar energy appear to be promising enough to give it a thorough test. First, solar energy is plentiful. There will be no shortage of primary energy in the combined potential of direct sunshine, photosynthesis, running water and wind. Second, it is already well distributed to the villages. There is no problem of transmission and distribution lines. Third, the technology to make use of this primary energy, although very imperfect and high priced, is progressing rapidly both in performance and costs. It is not known that solar energy will prove to be practical for village use, but it is sufficiently promising to warrant a careful test. If the widespread use of modern machinery becomes possible as a result of making energy available, the residential attractiveness of villages will improve and the quality of life for this majority of the world's population will be enriched. Thus, a great deal is dependent upon the outcome of the next few years' tests of solar energy in the villages of the developing nations. 16 refs.

419/81 ENERGY IN A FINITE WORLD: VOLUME 2. A GLOBAL SYSTEMS ANALYSIS. International Institute for Applied Systems Analysis (Laxenburg (Austria)). Ballinger Publishing Co., Cambridge, MA, USA (1981) 83p. US$40.00.

This volume contains studies on global energy systems by the International Institute for Applied Systems Analysis. The volume begins with a description of the global energy problem. This is followed by a consideration of the energy supply, including fossil energy, coal, nuclear, solar and other renewable energy sources, as well as a review of energy-system considerations. This is followed by a consideration of the constraints to energy utilization, including market penetration, an examination of the water-energy-land-materials-manpower requirements, climatic impacts, risks and standards. In considering a balance between supply and demand, an analytical approach presented defines two scenarios interpreting present projections and covering energy consumption and conservation, energy supply and conversion, alternatives and sensitivities and economic impacts. Consideration is also given to the issues of energy, entropy and endowments, up-dated old technologies, energy densities, land-use and settlement patterns and the hard versus soft controversy. In conclusion, the implications of various levels of energy demand are indicated involving both energy supply and constraints. 632 refs.

420/81 PAKISTAN'S APPROACH TO THE DEVELOPMENT OF RENEWABLE ENERGY - ITS RESOURCES AND PROBLEMS. M.S. Qureshi (Directorate General of Energy Resources, Ministry of Petroleum and Natural Resources, Islamabad (Pakistan)). Helios, no. 12, p. 1-5 (1981).

This review begins with a description of the problems facing Pakistan with regard to its attempt to procure adequate supplies of energy. To achieve the deployment of renewable energy, Pakistan has developed the concept of Energy Centres: a village or settlement which has an energy deficit but which has raw materials for biogas production and/or sufficient wind for conversion to useful forms of energy. The Energy Centre will involve the use of biogas, solar thermal, solar photovoltaic and possibly wind energy systems. Sometimes small-scale hydro and geothermal energy technologies will also be used. Some combination of these systems will provide fuel, electricity and power for cottage industries and irrigation. The strategy for the development and deployment of renewable energy sources adopted in Pakistan is outlined.

421/81 RENEWABLE ENERGY RESEARCH IN INDIA. Tata Energy Research Institute (Bombay House, 24 Homi Mody Street, Bombay 200023 (India)). Tata Energy Research Institute, Bombay, India (1981) 269p.

This directory describes the renewable-energy research programmes in 3 government departments, 44 academic institutions and universities, 7 industrial companies, and 9 state government and community agencies in India. Solar, wind, biomass, tidal, hydrogen, magnetohydrodynamic and draft-animal power research projects are included.

422/81 MOROCCO ENERGY STUDY. Office of Energy Development Support Bureau, Agency for International Development, US Department of State, Washington, DC 20532 (USA)). Report PN-AAH-218. Agency for International Development, Washington, DC, USA (1978) 63p.

This report examines the energy situation in Morocco with regard to supplies of oil shale, hydropower, solar and biomass energy. Energy investment and economic development options are also examined. 12 refs.

423/81 PROCEEDINGS OF INTERNATIONAL WORKSHOP ON ENERGY SURVEY METHODOLOGIES FOR DEVELOPING COUNTRIES. Board of Science and Technology for International Development (Commission of International Relations, National Academy of Sciences - National Research Council, Washington, DC (USA)). (Held Jekyll Island, GA, USA, 21-25 January, 1980). National Academy Press, Washington, DC, USA (1980).

Aware that the developing countries must plan careful strategies for energy use and must utilize a wide range of energy sources, particularly renewable ones, this meeting was organized to examine the basis for obtaining good information about the energy supplies and consumption required for sound planning and effective action. The proceedings begin with a summary of the conclusions and recommendations of the meeting, and is followed by the reports of 4 working groups which examined rural, urban, industrial and transportation energy-survey methodologies and needs. This is followed by an annotated bibliography of 52 energy surveys for developing countries which includes general designs of energy surveys, energy assessments and data-analysis systems. Excerpts of 12 background papers prepared for the workshop compose the major appendix. 25 refs.

B. SOLAR ENERGY

424/81 CHINA VOTES FOR SUN. Lu Ti (China Features, Beijing (China)). Energy Developments, no. 4, p. 22-4 (1979).

China receives the equivalent of 1200 billion tonnes of coal annually in solar energy, two-thirds of its area receiving over 2000 hours per year and one region over 3200 h/y. Solar energy has been exploited since the 1950s, particularly in the use of collectors for heating water, solar dryers, grain dryers and solar cookers. Lighthouses are powered by silicon solar cells, distillation plants with 1 tonne/day capacity are in use, and research houses with active and passive solar heating and cooling have been constructed. An office block has been supplied with solar space heating, saving 80% of the normal winter fuel requirements.

425/81 AMERICAN INDIAN PROJECTS IN SOLAR ENERGY: COMMUNITY INVOLVEMENT. R.R. Winget, A.R. Miller and M. Edwards (Small Tribes Organization of Western Washington, Sumner, WA (USA)). P. 168-71 of Proceedings of the Solar 79 Northwest Conference (held Seattle, WA, USA, 10 Aug. 1979). NTIS. US$33.00 for the complete publication (CONF-790845).

Some American-Indian projects in solar energy are described with emphasis on the Pacific northwest and on community involvement. The projects covered include: the STOWW (Small Tribes Organization of Western Washington) Hot

Water Project, the Papago Photovoltaic Project, the Cowlitz Solar Greenhouse, and the Suquamish Solar Salmon Hatchery.

426/81 ARCHITECTURE AU NATUREL. D. Wright. P. 17-27 of Proceedings of Workshop on Solar Energy Applications: Solar Architecture (held Aspen, CO, USA, 27 May 1977). Ann Arbor Science Publishing Inc., Ann Arbor, MI, USA.

The process of architectural design which takes advantage of the knowledge of natural environmental factors in combination with modern technology, called microclimate design, is discussed. The role of microclimate design in determining how to best design a solar house is illustrated by numerous examples.

427/81 LOW-TEMPERATURE SOLAR COATINGS. R.J.H. Lin. P. 205-47 of Proceedings of the Thermal Power Systems Workshop on Selective Absorber Coatings (held Golden, CO, USA, 6 Dec. 1977). SERI/TP-31-061, Solar Energy Research Institute, Golden, CO, USA (1977).

Research at Honeywell Corp. on various coatings for improving solar-collector efficiency is described. Coatings investigated include selective-absorbing plated and painted coatings and anti-reflection coatings for window materials. Some results are given.

428/81 STRUCTURED COATINGS FOR SOLAR ENERGY COLLECTORS. V.K. Nagar, T.C. Tripathi and G.D. Sootha (National Physical Laboratory, New Delhi (India)). P. 62-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Structured selective coatings for solar energy applications have been developed by electroplating metals (Ni or Co) on specially treated metal substrates (Al, MS and Cu). The infra-red emittance from these coatings at temperatures up to 500 °C is very low. The absorptance of the films strictly depends on the surface structure of the substrate. Detailed SEM studies have been carried out with a view to optimize the surface structure and hence the absorptance by varying various surface treatment parameters. These coatings have been found fairly stable on thermal cycling even up to 400 °C. Total radiation losses for these coatings have been compared with lamp black, black paint and black chrome under identical meteorological conditions. The relative advantages of the present coatings over the selective coatings reported so far are discussed.

429/81 THE SELECTIVE SOLAR ABSORPTANCE OF IN SITU-GROWN OXIDE FILMS ON METALS. D.L. Douglass and R.B. Pettit (Department of Materials Science and Engineering, University of California, Los Angeles, CA 90024 (USA)). Solar Energy Materials, vol. 4, p. 383-402 (1981).

The solar absorptance and emittance were measured for a number of generic oxides grown in situ on a variety of pure metals and alloys. The surface films were formed by reacting the substrates in air, pure oxygen or high-temperature high-pressure water to give a range of thickness for each oxide. The oxide-metal systems investigated included ZnO and/or Cu_2O on Cu-30 Ni, Cu_2O on aluminium bronze and Cu-5 Al, NiO on nickel. TiO_2 on titanium, ZrO_2 on Zircaloy-2, Fe_2O_3 on iron, Fe_2O_3 on type 201 stainless steel. Fe_3O_4 on Kovar, Cr_2O_3 on chromium-coated steel and Al_2O_3 on Kanthal A-1. Optical properties depended markedly on film thickness. Only two oxides, NiO and ZrO_2, had a combination of high solar absorptance (greater than 0.8) and low 100 °C emittance (less than 0.3). A third oxide, Cu_2O, had an α of 0.74 and an ε of 0.25, which combination also appeared interesting. The oxide films were tenacious and exhibited no tendency to spall. Although the optical properties were encouraging, they were not optimum. All films had been formed on polished substrates, and no attempts were made to improve the solar absorptance by changing the surface topography. Attempts to rationalize selective solar absorption on theories involving the index of refraction of the films or the band-gap energies are only partially successful. There is little basis for selecting candidate oxides based on physical properties. 11 refs.

430/81 NICKEL PIGMENTED ANODIC ALUMINUM OXIDE FOR SELECTIVE ABSORPTION ON SOLAR ENERGY. A. Andersson, O. Hunderi and C.G. Granqvist (Graenges Aluminum, S-612 21 Finspang (Sweden)). Journal of Applied Physics, vol. 51, p. 754-64 (1980).

Spectrally selective surfaces on Al metal sheets were prepared by DC anodization in dilute phosphoric acid followed by black coloration via AC electrolysis in a bath containing $NiSO_4$. These coatings had good durability, as found from several accelerated tests. The optical performance was studied by the recording of hemispherical reflectance or specular reflectance in conjunction with diffuse-light scattering. From these results, a solar absorptance of 0.93-0.96 and a corresponding thermal emittance of 0.10-0.20 were extracted. The structure of the coatings was investigated by scanning electron microscopy on fractured specimens, Auger electron spectroscopy combined with depth profiling by sputtering, and atomic absorption analysis. Based on this information, a multilayer model was formulated, its most conspicuous feature being a sheath near to the Al interface comprised of metallic Ni particles in an Al_2O_3 matrix. The optical properties of this layer were described either by the Maxwell-Garnett theory or the Bruggeman theory, which are applicable to different microstructures. The latter formulation, together with a matrix technique to account for the multilayer configuration, was capable of giving quantitative agreement with the measured spectral reflectance, especially when reasonable estimates of surface roughness and of particle shape and orientation were invoked.

431/81 SOLAR PHOTOELECTROLYSIS WITH SEMICONDUCTOR ELECTRODES. H. Gerischer (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, Berlin 33 (Fed. Rep. of Germany)). P. 115-72 of Solar Energy Conversion: Solid-State Physics Aspects. B.O. Seraphin (ed.), Springer Verlag, Berlin, Fed. Rep. of Germany (1979).

The basic principles of photo-electrochemical devices with semiconductor electrodes as the energy converters are explained. Emphasis is placed on material problems, such as the susceptibility of semiconductors to decomposition. The function and efficiency of regenerative solar cells are described, and the conversion efficiency is discussed in relation to material properties. Guidelines for the selection of optimal materials are developed in analogy to photovoltaic conversion schemes. 118 refs.

432/81 PHOTOVOLTAIC CONVERSION BY MACROMOLECULAR THIONINE FILMS. R. Tamilarasan and P. Natarajan (Department of Chemistry, University of Madras, Tiruchirapalli 620020, Tamil Nadu (India)). Nature, vol. 292, p. 224-5 (July 1981).

On excitation by light, thionine dye oxidizes Fe^{2+} ions in solution and the photoproducts undergo dark reactions to restore the starting materials. The photogalvanic (photovoltaic) potentials generated by this cyclic process can be demonstrated by means of a cell with two platinum electrodes, one illuminated and one in the dark. Light is converted more effectively into electricity in the totally illuminated thin-layer cell with platinum and tin oxide electrodes, but the efficiency of the conversion is limited by energy-wasting back reactions in solution and by restriction on the concentration of the dye. These limitations can be overcome if thick films ($\sim 10\ \mu m$) of thionine condensed with macromolecules are coated onto inert electrodes. 11 refs.

B1. Radiation Measurement

433/81 INSTRUMENTATION FOR SOLAR RADIATION MEASUREMENTS. D. Anson (Lawrence Berkeley Laboratory, Berkeley, CA (USA)). P. 173-97 of Part A of Solar Energy Technology Handbook. W.C. Dickinson and P.N. Cheremisinoff (eds.). Marcel Dekker, Inc., New York, NY, USA (1980).

A survey of solar radiation-measuring instruments and a description of common types are presented. Sources of measurement errors arising from instrumental, operational and environmental causes are considered. 43 refs.

B2. Photovoltaic Conversion

434/81 ELECTRICAL PROPERTIES OF Zn^+-DOPED (AlGa)As PREPARED BY MOLECULAR BEAM EPITAXY AND ITS USE IN SHALLOW JUNCTION SOLAR CELLS. Suzuki T., Konagai M. and Takahashi K. (Tokyo Institute of Technology, Ōokayama, Meguro-ku, Tokyo (Japan)). Thin Solid Films, vol. 60, p. 85-9 (1979).

For the first time Zn^+-doped (AlGa)As (of p-type) was prepared by increasing the sticking coefficient through the ionization of Zn atoms. The positive-hole concentration of the p-layer is 10^{16}-$10^{19}\,cm^{-3}$. This result is as good as the results obtained with Mg and Be doping. A solar cell was made using a p-GaAs epitaxial film, which exhibited reduced surface recombination. The efficiency obtained was 12.6%. 5 refs.

435/81 HIGH EFFICIENCY GaAs SOLAR CELL DEVELOPMENT. FINAL REPORT, 1 AUGUST 1976-1 July 1978. S. Kamath and G. Wolff (Hughes Aircraft Co., Los Angeles, CA (USA)). AD-A-06616 (Jan. 1979) 106p. NTIS. US$13.50.

The major goals of the High Efficiency Gallium Arsenide (GaAs) Solar Cell programme have been met. An AMO efficiency of 17.5% was achieved. Radiation resistance of the cell without loss of efficiency was optimized, thus improving suitability of the cell for space missions.

436/81 HIGH EFFICIENCY n-CdS/p-InP SOLAR CELLS PREPARED BY THE CLOSE-SPACED TECHNIQUE. Yoshikawa A. and Sakai Y. (Tokyo Institute of Technology, Ōokayama, Meguro-ku (Tokyo)). Solid-State Electronics, vol. 20, No. 2, p. 133-7 (Feb. 1977).

Heterojunction solar cells have been made by epitaxial growth of CdS on p-type InP using the close-spaced technique. Good rectification and photovoltaic properties have been observed in the cells grown on the (110) face of InP. The characteristics of the most efficient cell are $V = 807\,mV$, the fill factor = 0.74 and the power-conversion efficiency = 14.4% under a solar input of 77 mW/cm^2. The photovoltaic properties of the cells obtained in this experiment are better than those reported elsewhere. This is attributed to the superiority of the growth system in that the junction is formed at a relatively high temperature in a short time. 20 refs.

437/81 RELIABILITY STUDIES ON MIS AND TRANS-

PARENT OXIDE-Si SOLAR CELLS. W.A. Anderson and J.K. Kim (Electrical Engineering Department, Rutgers University, Piscataway, NJ (USA)). P. 48-56 of Semiconductor Measurement Technology (Proceedings of the National Bureau of Standards - Department of Energy Workshop on Stability of (Thin Film) Solar Cells and Materials). NBS 400-58 (Aug. 1979). National Bureau of Standards, Department of Commerce, Washington, DC, USA.

Cr oxide/p-type silicon structures have achieved energy-conversion efficiencies of 12.2% using single-crystal silicon, and 8.8% with polycrystalline-silicon substrates. For these devices, an anti-reflection coating improves stability, but moisture penetration of the encapsulation must be avoided to prevent degradation. SnO_2/Si solar cells have exhibited significant degration in the form of increased resistance, decreased fill factor and variation in V_{OC}, caused by the formation of an SiO_2 film between the SnO_2 and Si due to field-assisted transport of O_2 from the SnO_2 to the Si. In In_2O_3/Si cells, degration was noted for temperatures over 300 °C, also caused by SiO_2 formation. In addition, the use of aluminium contacts resulted in the formation of Al_2O_3. 8 refs.

438/81 PROCESS TO REDUCE THE MANUFACTURING COST OF MONOCRYSTALLINE SOLAR CELLS. H. Lauvraya and Y. Salles (RTC, Suresnes (France)). P. 92-103 of Proceedings of the Photovoltaic Solar Energy Conference (held Luxembourg, Luxembourg, 27 Sept. 1977). D. Reidel Publishing Co., Boston, MA, USA (1978).

A technique which results in reduced manufacturing costs of mono-crystalline solar cells is discussed. It is recommended that ingot material loss be reduced to a minimum and that the diameter be made larger (over 100 mm). In this connection various experiments were carried out in order to find the most suitable slicing technique. Straight blades and diamond-wire saws are considered to be good choices. The data obtained using a trial cell were 12-13% at AM1 and at 25 °C with a 100-mm diameter cell. The sandwich encapsulation method using a glass-polyvinylbutyl-solar cell-polyvinylbutyl-glass structure is used in view of its mechanical strength and transmittivity.

439/81 NEW TECHNIQUE FOR FABRICATION OF pnn POLYCRYSTALLINE SILICON SOLAR CELLS BY SIMULTANEOUS DIFFUSION OF BORON AND PHOSPHOROUS INTO SILICON. S.N. Singh, R.K. Kotnala and N.K. Arora (National Physical Laboratory, New Delhi (India)). P. 267-72 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Investigations were carried out to develop a technique to fabricate pnn^+ poly-crystalline silicon solar cells by simultaneously diffusing boron into an n-silicon wafer from one side and phosphorous from the other at approximately 1100 °C with no significant cross doping of the p-region and the exposed p-n junction at the periphery. It has been found that using boron preform (paper source) as the p-type and phosphoresilica film as the n-type diffusant sources, the simultaneous diffusion of boron and phosphorous into an n-poly-crystalline silicon wafer through an approximately 1-μm thick layer of silicon dioxide at approximately 1100 °C for 10 minutes gives a practically cross-doping free pnn^+ structure. However, the cross doping becomes significant as the diffusion time t_d is increased. Still, for t_d less than or equal to 25 minutes an edge, cleaning to remove a less than or equal to 100 μm-wide silicon layer from the periphery of the cell is able to ensure good I-V characteristics of the solar cell. This technique has been used to fabricate pnn^+ polycrystalline silicon solar cell at the National Physical Laboratory, New Delhi. An AM1 conversion efficiency of 8.5 to 10% has been achieved using wafers from a directionally frozen polycrystalline silicon rod of 16-mm diameter with yield as high as 60% on batches of 70 to 100 pieces.

440/81 SILICON WEB PROCESS DEVELOPMENT. LOW COST SOLAR ARRAY PROJECT, LARGE AREA SILICON SHEET TASK. QUARTERLY REPORT, OCTOBER 1, 1978-DECEMBER 31, 1978. C.S. Duncan, R.G. Seidensticker, R.H. Hopkins, J.P. McHugh, F.E. Hill, M.E. Heimlich and J.M. Driggers (Research and Development Center, Westinghouse Electric Corp., Pittsburgh, PA (USA)). DOE/JPL-954654-6 (1978) 117p. NTIS. US$13.50.

Silicon dendritic web is a ribbon form of single-crystal silicon produced directly from the melt without the use of dies or shapers, Solar cells fabricated on such a web have exhibited conversion efficiencies of 15.5% - the highest yet for a ribbon form of silicon. The primary objectives of this programme are to develop techniques to grow silicon web at 25 cm^2/min output rate and demonstrate the feasibility of web growth with simultaneous melt replenishment. The methods developed are to be compatible with efficient solar cell performance. During this quarter the focal points of the effort have been: (1) tests of after-trimmers to improve web width; (2) evaluation of growth lid designs to raise speed and output rate; (3) tests of melt replenishment hardware; and (4) investigation of directed gas-flow systems to control unwanted oxide deposition in the system and to improve convective cooling of the web. Technical progress is reported in detail.

441/81 PHOTOVOLTAIC CELLS: TRANSFORMING THE SUN'S RAYS INTO ELECTRICITY. R. Gibbs. R&D Mexico, vol. 1, no. 8, p. 16-22 (1981).

This article describes work carried out on photovoltaic cells by the Department of Electrical Engineering at the Centre for Research and

Advanced Studies (CINVESTAV) of the National Polytechnic Institute (IPN) in Mexico. This department has integrated its basic research into an overall programme to develop technologies transferable to industry. The department installed a pilot-production plant which by the end of 1980 fabricated more than 20,000 single-crystal silicon solar cells. The first demonstration project was established by the department in the Sierra Madre Mountains to provide educational television for an isolated village. The success of the system, which paid for itself within 2 years, has attracted the interest of other villages in the region. Solar cell produced electricity is envisaged by the department as offering a wide variety of feasible solutions to the energy needs of rural Mexico.

442/81 SUNLIGHT ON SILICON CELLS - ELECTRICITY. Agricultural Engineering, vol. 58, no. 11, p. 18-20 (Nov. 1977).

This paper reports that some 100,000 solar cells convert sunlight into electricity to drive the 7.5-W pump that distributes the irrigation water for 0.32 km^2 of corn at the University of Nebraska's field laboratory at Mead. In the flat-plate collectors, each silicon cell is 0.8-1.2 cm in diameter and 0.008-cm thick. Each cell can generate power equal to about 0.25 W around noon on a sunny day. A thin grid of collector wires on top of each cell takes the charge to contacts at the side. A positive-negative junction is formed by exposing one portion of the cell surface to high-temperature phosphorus. These silicon cells are mounted on 28 flat panels in two rows of collectors. Each row is 2.7 m wide and 120 m long.

443/81 PHOTOVOLTAIC POWER SYSTEM RELIABILITY CONSIDERATIONS. (Lewis Research Center, National Aeronautics and Space Administration, Cleveland, OH (USA)). NASA-TM-79291 (1979) 10p. NTIS. US$7.50.

An example of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems is described. This particular application was for a solar cell power-system demonstration project in Tangaye, Upper Volta, one of two photovoltaic village power projects currently managed by the Photovoltaic Project Office. The techniques involve a definition of the power system, natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of a failsafe and planned spare-parts engineering philosophy. The Tangaye system has been operating since 1 March 1979. This is the second photovoltaic system designed to provide electric power requirements for remote villages. The first village power system was installed at Schuchuli, AZ, USA in Dec. 1978.

B3. ACTIVE THERMAL SYSTEMS

444/81 TECHNOLOGY OF FLAT PLATE COLLECTORS. A.A.M. Sayigh (University of Riyadh, Riyadh (Saudi Arabia)). P. 101-24 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

The capabilities and limitations of flat-plate collectors are discussed with the intention of promoting their proper use, especially in developing countries. The optimization of the air gap between the absorber and glass cover is considered. Practical points regarding the manufacture of flat-plate collectors are given, including types of adhesive, insulation material, allowance for glass expansion and ways to alleviate freezing and infrared radiation losses. 23 refs.

445/81 ELEMENTARY PROPERTIES OF A REVERSE FLAT PLATE TYPE SOLAR HEAT COLLECTOR DEVELOPED FOR COLLECTING TOTAL INSOLATION (全天日射を対象とした逆平板型コレクターの基礎特性). Sakuta K., Tani T., Sawada S., Tanaka T. and Horigome T. (Electro-Chemical Laboratory, Tanashi, Tokyo (Japan)). P. 9-12 of Proceedings (Kōen Ronbunshū) of the Third Research Presentation Meeting (Dai-Sankai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nihon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 5-6 Dec. 1977). Japan Solar Energy Society, Bunkyo-ku, Tokyo, Japan (1977). In Japanese.

A non-concentrating solar heat collector of the reverse flat-plate type was developed for the purpose of providing a solar heat collector of reduced cost for a solar energy system. An experimental programme was undertaken to perform the comparative experiments of a small-scale test model and a flat-plate solar heat collector. The results of the experiments and the elementary properties of the test model are described.

446/81 HEAT-TRANSMISSION DEVICE FOR SOLAR HEATING SYSTEMS. E.A. Nasonov and Y.I. Bondarenko (Tashkent Zonal Scientific Research Institute for Experimental Design of Residential and Public Building, Tashkent, Uzbek SSR (USSR)). Applied Solar Energy, vol. 16, p. 59-64 (1980) [English translation of Гелиотехника, 16, p. 56-61 (1980)].

A device without pump is described that can transfer heat downward over distances of several meters. The theoretical relationships governing its operating regimes are given together with the results of experimental investigations. Two arrangements are proposed for solar-heating systems that utilize the given heat-transmission unit.

447/81 SOLAR HEATING SYSTEM FOR KILN DRYING LUMBER. P.O. McCormick (Energy Systems Section, Lockheed-Huntsville Research and Engineering Center, Huntville, AL (USA)). Sunworld, vol. 4, p. 204-7 (1980).

This article describes a one-year test of two solar-heating systems for lumber kilns in Canton, MI, USA. The kiln drying schedule, solar energy-collection and storage systems, and instrumentation and data systems are outlined. Data for collectors and system performance are provided. The system is seen to be quite satisfactory, although problems in detailed data collection on a continuous basis appear to be difficult.

448/81 PERFORMANCE OF AN EXPERIMENTAL REGENERATIVE-EVAPORATIVE COOLER COMPARED WITH PREDICTIONS. H. Buchberg and N. Lassner (University of California, Los Angeles, CA (USA)). P. 629-40 of Proceedings of the Conference on Heat and Mass Transfer in Buildings (held Dubrovnik, Yugoslavia, 29, Aug. 1977). Hemisphere Publishing Corp., Washington, D.C., USA.

An experimental regenerative-evaporative cooling system has been designed, constructed, and tested in the laboratory under simulated environmental conditions. It represents the first phase of an investigation of solar desiccant evaporative-cooling processes applied to space cooling with the goal of substantial reduction in electric-power usage for air conditioning. The test measurements were used to validate and refine an analytical-performance model programmed for computing. Performance graphs are generated which permit the determination of supply-air temperature, room-air temperature and humidity for a specified air flow; latent and sensible heat load; and heat-exchanger carryover ratio. Predictions of room-air temperature are within 0.94 C° or less and a room-air humidity ratio within 0.0008 or less of observed performance. Supply-air temperature was predicted within 0.47 C° or less. Based on a design capacity of 3.5 tonnes of cooling at an air flow of 1,180 l/s, it is estimated that a cooling effect to electrical-power usage ratio between 8 and 10 is achievable. The experimental system is capable of providing 3.5 tonnes of cooling when delivering air at 20 °C when the outside air is at 38 °C with humidity=0.0103. For these conditions, 1,180 l/s of supply air maintains a room temperature of 25 °C at 70% relative humidity when 1/3 of the load is latent heat.

449/81 PRELIMINARY TESTS OF SOLAR UNIT FOR REDUCTION OF HEAT CONTENT AND EVAPORATIVE COOLING OF AIR. O. Klyshchaeva (Turkmen Polytechnical Institute, Ashkhabad, Turkmen SSR (USSR)). Applied Solar Energy, vol. 16, p. 37-40 (1980) [English translation of Гелиотехника, vol. 16, p. 35-8 (1980)].

A unit based on evaporative cooling and reduction of air heat content through treatment with a concentrated salt-water solution is considered.

450/81 CHEAP ROOF TYPE SOLAR AIR HEATERS FOR INDUSTRIES. V.R. Muthveerappan and K. Iynkaran (Annamalai University, Annamalainagar (India)). P. 703-8 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

One of the potential applications of solar energy is in the production of warm air. Warm air is widely used for drying operations in industries and in building heating. The initial cost of solar air heaters can be brought down if they can be suitably designed to adopt existing roofing with some modifications. A few types of such cheap collectors have been discussed in this paper. Experimental results from one such type is reported. The economics of such a roof-type solar air heater is also presented. While recommending solar air heating for industries, one must be very careful about the economical feasibility of such a system. Emphasis has been made in developing a very cheap collector for this purpose.

451/81 THE GFL METHOD FOR SIZING SOLAR ENERGY SPACE AND WATER HEATING SYSTEMS. G.F. Lamerio and P. Bendt (Solar Energy Research Institute, 1536 Cole Boulevard, Golden, CO 80401 (USA)). Report SERI-30. SERI, Golden, CO, USA (1978) 40p.

This report describes the development and utilization of the GFL sizing procedure for designing solar energy space and domestic hot-water heating systems. It can be used for both air and liquid solar energy collectors. The principal advantage to the GFL method is its ease and simplicity of use. This method requires only the evaluation of several simple algebraic equations. Hence, neither computers nor programmable calculators are required. A typical design example requires about five minutes to compute by hand or less than one-tenth of a second by computer. The GFL method was validated by making over 1,500 side-by-side comparisons with different collector types (air and liquid), different collector design parameters, in different locations (151 US locations), and for a range of f-values from 0 to 90%. Additionally, an independent consultant made 500 side-by-side comparisons. 7 refs.

452/81 SOLAR POWERED LIQUID PISTON STIRLING CYCLE IRRIGATION PUMP. Centre for Environmental Research and Development (University of New Mexico, Albuquerque, NM (USA)). SAN-1894/1 (10 April 1979) 29p. NTIS. US$9.00.

Project objectives and work performed during the duration of the grant included construction of a laboratory prototype of the liquid-piston Stirling-cycle heat engine with modelling and simulation, a range of engine sizes to determine lift-head ranges, capacities and principles of operation. A preliminary investigation of solar energy inputs indicates numerous feasible methods to operate heat engines. The maximum rate of pumping obtained was one liter per 26 seconds through a 109-cm lift head.

453/81 STEAM TURBINE INSTALLATIONS WITH ORGANIC WORKING FLUIDS, AND THE OUTLOOK FOR USING THEM IN SOLAR ENGINEERING. V.A. Grilikhes, M.M. Grishutin and V.S. Evseev. Гелиотехника, no. 4, p. 3-18 (1978). In Russian [English translation in Applied Solar Energy vol. 14 (1978)].

Consideration of thermo-physical and operational-technological factors shows that organic compounds are the best choice as working fluids in steam turbines utilizing low-potential heat sources. The fluids that are used in such applications include Freon-12, Freon-114, thiophene, toluene, benzene and a eutectic of 26.5% diphenyl and 73.5% diphenyl ether. The properties of these fluids are compared with those of water. Some of the technological problems involved in using organic fluids for steam-turbine operation are considered, and an examination is made of the way that the specific properties of organic working fluids influence the organization of the various elements of the power-facility turbines, piston expanders and heat-exchange equipment (steam generator, regenerator and condensers). It is shown that the use of organic working fluids in steam-turbine facilities based on low-potential heat sources can appreciably reduce specific capital investments.

454/81 SOLAR POWERED IRRIGATION AND THE NML/BATTELLE SOLAR PUMP. F.G. Dawson, G. Alexander and P.L. Hofmann (Battelle Memorial Institute, Columbus, OH (USA)). P. 105-10 of Soltech '78 (Proceedings of the Middle East Solar Technical Exhibition and Conference, held Manama, Bahrain, 24 April 1978). UK Section of International Solar Energy Society, London, UK (1978).

The feasibility of using solar energy for irrigation is discussed and the United States solar irrigation-system research programme is reviewed. The 37-kW solar-irrigation system at Gila Bend, Arizona, USA, is described. The system employs parabolic collectors and a solar heat engine.

455/81 DESIGN OF A 150 kW SOLAR-POWERED IRRIGATION FACILITY. D. Rafinejad (Acurex Corporation, CA (USA)). International Power Generation, vol. 2, no. 5, p. 27-37 (1979).

Irrigation water for a farm near Coolidge, AZ, USA, is pumped from wells 115-m deep using power supplied by a 4550-m^2 field of parabolic trough collectors. The thermal energy is converted to electricity to drive the pumps via an organic Rankine-cycle engine. The system includes a 114-m^3 thermal-storage tank to act as a buffer during insolation transients, and to enable system operation at night.

B4. PASSIVE THERMAL SYSTEMS

456/81 NATURAL AND CONVECTED AIR DRYING OF CASSAVA CHIPS. L.G. Villa, G. Roa and O. Braunbeck (Universidade Estadual de Campinas, Campinas, São Paulo (Brazil)). American Society of Agricultural Engineers Technical Paper 28 (1979), (From ASAE and Canadian Society of Agricultural Engineering Summer Meeting, held Winnipeg, Canada, 24 June 1979). American Society of Agricultural Engineers, USA.

In this paper results of improved methods of using solar energy for drying cassava chips are presented. A natural-convection system to be used in regions without electricity is described. For more developed areas and higher productions, a forced-convection system is also described. An empirical equation for predicting the natural drying of cassava chips is presented.

457/81 A SIMPLE SOLAR RICE DRYER: BASIC DESIGN THEORY. R.H.B. Exell (Asian Institute of Technology, P.O. Box 2754, Bangkok (Thailand)). Sunworld, vol. 4, p. 186-91 (1980).

Details are given of the elementary theoretical calculations required for the design of a simple flat-bed grain dryer in which solar-heated air rises by natural convection through the grain. Data are given for rice drying in a tropical monsoon climate where the dryer enables farmers to dry their second crop during the wet season and to harvest at a low cost.

458/81 PERFORMANCE OF A LARGE, SALT-GRADIENT SOLAR POND. L.J. Wittenberg and M.J. Harris (Mound Facility, Miamisburg, OH (USA)). Proceedings of the Fourteenth Intersociety Energy Conversion Conference (held Boston, MA, USA, 5 Aug. 1979). MLM-2616(OP) (1979) 4p. NTIS. US$7.50.

Initial performance data collected from the largest salt-gradient solar pond in the USA indicate that it has the potential to be a very low-cost solar-heating system. The solar pond at Miamisburg, OH, USA, occupies an area of 2000 m^2 and was installed for only US$35/m^2. The pond is predicted to deliver 281,000 kWh/y and to be used principally for heating an outdoor swimming pool in the summer and a recreation building during October-December. Based upon straight amortization of 10%/y, this heat is predicted to cost US$0.025/kWh.

459/81 NON-CONVECTING SOLAR PONDS. H. Tabor (Science Research Foundation, Jerusalem (Israel)). Philosophical Transactions of the Royal Society of London, ser. A, no. 1414, p. 423-33 (1980).

The results of an experimental study on a magnesium chloride solar pond are presented. The annual production of thermal energy for a 1-km^2 solar pond in Israel is determined. A method for preventing diffusion of the salt is described. 18 refs.

460/81 LOW TEMPERATURE INDUSTRIAL PROCESS HEAT FROM NON-CONVECTING SOLAR PONDS. T.L. Ochs and J.O. Bradley (Desert Research Institute, Boulder City, NV (USA)). P. 139-43 of Proceedings of the Solar Industrial Process Heat Conference (held San Francisco, CA, USA, 31 Oct. 1979). SERI/TP-333-429 (1979).

A unique class of integrated solar collector-storage concepts are described. A variety of non-convecting solar ponds are surveyed and ranges, performance, and costs are discussed.

461/81 PROCEEDINGS OF THE DESICCANT COOLING CONFERENCE. B. Shelpuk (Solar Energy Research Institute, 1536 Cole Boulevard, Golden, CO 80401 (USA)). (Held 16 Nov. 1977). Report SERI-22. SERI, Golden, CO, USA (1978) 96p. US$11.50.

This report presents an overview of adsorption processes applied to solar cooling and a summary of the proceedings of a meeting on the current status of the technology. The meeting focused on a discussion of existing US Department of Energy programmes and on the extent to which they are able to deal with the important research issues identified by the participants. Descriptions of existing programmes are included, and remaining key issues are summarized along with suggestions for their resolution. A data base of related literature is included as an appendix. 42 ref.

462/81 PASSIVE COOLING SYSTEMS IN IRANIAN ARCHITECTURE. M.N. Bahadori (Shiraz University, Shiraz (Iran)). P. 164-76 of Proceedings of the Third Workshop on the Use of Solar Energy for the Cooling of Buildings (held San Francisco, CA, USA, 15-17 Feb. 1978). Oct. 1978. NTIS. US$22.50 for the complete proceedings (CONF-780249).

In Iran, certain traditional building designs circulate cool air and can even keep water cold and ice frozen from the winter until the height of the long hot summer of the country's arid central and eastern plains. They do so without any input of energy other than that of the natural environment; hence they can be characterized as passive cooling systems. Some of these systems, for example the curved-roof systems, were incorporated in buildings as early as 3000 BC; others, for example the wind tower systems, the cistern and the ice maker, may not have appeared until about 900 AD. Many of the passive cooling systems are still in use at present. The design and operation of the wind-tower cooling system, the cistern cooling system, and the nocturnal radiative-cooling ice maker are described.

C. BIOCONVERSION ENERGY

463/81 SEPARATION - A PROCESS TO ECONOMICALLY CONVERT SUGAR CANE BIOMASS TO FUEL ALCOHOL AND HIGH VALUE BOARD PRODUCTS. C.K. Laurie (Sugar Cane Consultants, Ltd., P.O. Box 3B (Barbados)). P. 222-8 of Caribbean Consultation on Energy and Agriculture (Consulta del Caribe Sobre Energia y Agricultura). Instituto Superior de Agricultura, Santiago, Chile (1980).

Energy from biomass would appear to be one of the best sources of alternate energy for the tropics. The sugar-cane plant seems to be the most appropriate renewable source of biomass for developing countries in the Caribbean. The use of the sugarcane plant to produce high-value products, such as structural panel boards, would appear to be a most appropriate method of simultaneously producing ethanol for fuel at prices that can compete with gasoline. The multiple use of all parts of the sugarcane plant should allow small-scale development of integrated systems which efficiently produce building products and sugar or alcohol simultaneously. 4 refs.

La obtención de energía a partir de biomasa parece ser una de las mejores fuentes alternativas de energía en los trópicos. La planta de caña de azúcar parecer ser la fuente renovable de biomasa más apropiada para los países subdesarrollados del Caribe. El uso de la planta de caña de azúcar para generar productos de alto valor energético, como paneles estructurales, parece ser un método sumamente apropiado para simultáneamente producir etanol como combustible a precios que puedan competir con la gasolina. El uso múltiple de todas las partes de la planta de caña de azúcar debería permitir el desarrollo eficiente de sistemas integrados en pequeña escala en los cuales se podría producir leche o carne, productos de construcción y azúcar o alcohol simultáneamente. 4 ref.

464/81 ELECTRICITY FROM THE SUGAR CANE INDUSTRY IN NICARAGUA. J. Baguant (School of Industrial Technology, University of Mauritius, Reduit (Mauritius)). Interciencia, vol. 6, p. 77-80 (1981).

For Nicaragua in 1975 and 1976, 55% to 60% of the electricity demand was met by imported fossil fuel. This short survey shows that almost 26% of the electricity required could now be met by the existing sugar-cane industry and without further expansion of the sugar-cane crop production. This can be increased to around 35% by processing the tops and leaves of the sugar-cane plant. There also is sufficient potential for biomass utilization for fuels or chemical feed-stocks in Nicaragua to justify prompt attention to this additional option. 11 refs.

En Nicaragua, del 55 al 60% de la demanda de electricidad durante los años 1975 y 1976 fue suministrada con combustible fósil importado. La breve reseña que aquí se presenta muestra que casi el 26% de la electricidad que se necesita en el país podría ser suministrada de immediato por la industria de caña de azúcar ya existente, y sin que sea necesario aumentar la producción de caña. Esta cifra podría aumentar hasta más o menos un 35% si se procesan también el follaje y el cogollo de la planta. Hay asimismo en Nicaragua suficiente potencial para la utilización de biomasa en la elaboración de combustibles y forraje químico que justifique un enfoque a corto plazo de esta opción. 11 réf.

C1. Biomass Production and Conversion

465/81 HYDROCARBON FUELS FROM PLANTS. L.W. Hillen, L.V. Wake and D.R. Warren (Aeronautical Laboratory, Melbourne, Victoria 3001 (Australia)). Fuel, vol. 59, p. 446-7 (1980).

This article presents a study of algae, Botryococcus brauni, containing hydrocarbons harvested in an Australian lake. Tests were made to distil the oil extracted from this algae. 13 refs.

466/81 ISRAELI SCIENTISTS FOCUS ON FARMING SEAWEED FOR OIL. Chemical Engineering, vol. 83, no. 4, p. 62 (16 Feb. 1976).

A pollution-free process to convert Dunaliella, a salt-water seaweed, to high-grade synthetic crude oil has been developed to a preliminary stage. In the farming scheme, Dunaliella would be grown in a string of desert salt-water solar ponds, where it would have a "most impressive" growth rate. The crop could readily be harvested with little mechanical energy. In the laboratory-autoclave procedure, a high-temperature reducing gas converts an aqueous slurry of algae into oil, and alkaline catalysts help drive the reaction. Oil yields have been called "satisfactory". The project has been split up into teams that will try to increase the efficiency of raising the seaweed, find the least energy-intensive harvesting method, genetically alter the algae to raise their organic content, and improve the conversion process.

467/81 PRESENT SITUATION OF ENERGY PLANTATIONS (エネルギー植物開発の現況). Kawai A. Journal of the Fuel Society of Japan (Nenryō Kyōkai Shi), vol. 59, no. 3, p. 182-90 (1980). In Japanese.

This article reviews the following points: the technology for utilizing biomass, the factors required for an energy plantation and the present status of studies on Euphorbia lathyrus, E. tirucalli and Eucalyptus globulous.

468/81 TECHNO-ECONOMIC FELLING CYCLES FOR SELECTED ENERGY PLANTATION SPECIES IN THE ARID AREAS OF WESTERN RAJASTHAN. J.C. Kalla, C. Gyan, D.L. Vyas and N.S. Gehlot (Central Arid Zone Research Institute, Rajasthan (India)). Annuals of Arid Zone, vol. 17, no. 1, p. 42-51 (1978).

Analysis of data collected from research plots at Pali, Rajasthan, predicted that the maximum fuel yields per tree would be reached at rotations of 50 years for (a) Azadirachta indica (51 kg), 25 years for (b) Acacia tortilis (39 kg), 14 years for (c) Albizzia (Abizia) lebbek (15 kg) and 13 years for (d) Acacia nilotica (6 kg). The best economic rotations would be 23 years for (a) yielding 24 kg/tree, 8 years for (b) yielding 20 kg/tree and 11 years for (c) yielding 6 kg/tree. Harvesting Acacia for fuel would not be economic.

469/81 ETHANOLIC FUELS FROM RENEWABLE RESOURCES IN THE SOLAR AGE. H.P. Gregor and T.W. Jeffries (Department of Chemical Engineering and Applied Chemistry, Columbia University, New York, NY (USA)). PB-295645 (1979) 34p. NTIS.

This communication describes how ethanol, other liquid fuels, and organic chemicals can be produced from cellulosic biomass at prices that can compete with those of petroleum-derived materials by employing presently available or soon to be developed membrane technologies. Contemporary membrane technologies can already effect major savings in process costs for the conventional fermentation of grains or molasses to produce ethanol; developing membrane technologies could employ cheap cellulosic substrates for ethanol production.

470/81 PROCESS DEVELOPMENT STUDIES ON THE BIOCONVERSION OF CELLULOSE AND PRODUCTION OF ETHANOL. C.R. Wilke and H.W. Blanch (Lawrence Berkeley Laboratory, University of California, Berkeley, CA (USA)). LBL-9220 (June 1979) 39p. NTIS. US$9.00.

The biosynthesis of ethanol from cellulose is discussed. The following topics are covered: enzymatic hydrolysis of corn stover; high-pressure hydrogen chloride process; cellulase production from Trichoderma viride by batch and continuous fermentation; studies on the composition of cellulase; enzyme recovery, media development, and growth factors in ethanol fermentation; xylose fermentation; and isolation of xylose fermentation; and isolation of xylose-fermenting organisms.

471/81 A DESIGN STRATEGY FOR THE IMPLEMENTATION OF STOVES PROGRAMMES IN DEVELOPING COUNTRIES. S. Joseph and Y.J. Shanahan (Stove Project, Intermediate Technology Development Group, A.R.S. Shinfield, University of Reading, Whiteknights, Reading, Berkshire (UK)). Appropriate Technology, vol. 8, no. 1, p. 21-2 (1981).

At least 10 stove programmes in Third-World countries have been initiated between 1955-75, but none have led to the widespread use of improved stoves resulting in a market reduction in the demand for biomass fuels. Reasons for the failures of these stove programmes are identified as resulting from political, cultural, historical, economic and technical factors. From an analysis of the problems of these stove programmes, a design strategy for a 6-stage programme to be implemented is outlined.

C2. Biogas Production and Utilization

472/81 RENEWABLE SOURCES OF ENERGY. VOLUME II. BIOGAS DIRECTORY. REPORT ST/ESCAP/160 (TCDC/SRD/3). Economic and Social Commission for Asia and the Pacific, Bangkok, Thailand (1981). 277p.

This expensive directory begins with a description of: biogas plants installed in the ESCAP region; uses of the products of biogas plants; methods of improving biogas-plant productivity; biogas activities in the ESCAP region; the economic, social and environmental aspects of biogas; and the scope for economic and technical co-operation in this field among developing countries. A cost-benefit analysis of an Indian biogas system is included. The bulk of the document is a compendium of 114 experts and 75 institutions working in this field in the ESCAP region. Information on the experts includes address, academic and professional qualifications, employment record, fields of interest, projects, and publications. Information provided for institutions is divided into institutional data and engineering data on biogas plants. 411 refs.

473/81 BIOGAS FOR THE RURAL COMMUNITY IN MAINLAND CHINA (BIOGAS PARA LA COMUNIDAD RURAL EN CHINA POPULAR). Ma Yi (Chinese Academy of Agricultural Mechanization Sciences, No. 1, Beishatan, Deneng Men Wai, Beijing (China)). Interciencia, vol. 6, p. 75-6 (1981). In Spanish.

It is estimated that each peasant family in China suffers from fuel scarcity during an average of three months per year. To help allay this situation, a total of 7,140,000 small biogas digesters have been built in the rural areas. In the Province of Sichuan, 20,000 of these digesters are large enough that they can drive diesel engines and generate electricity. The basic model is one built for individual home use in which human excrement (10%), pig and cattle dung and plant stalks (40%) plus water (50%) are utilized. The caloric value of organic matter through fermentation is 80% higher than if it is burned. Since in China there are some 1400 billion tonnes of excreta available per year, it is obvious that they represent a cheap and abundant source of energy. Furthermore, the use of digesters reduces by a factor of 95% the germs and parasites contained in feces. In one rural town, Dongxian, with 200 to 300 families, intestinal diseases were observed to be reduced by 80% after digesters were installed. Possible avenues of research to improve digesters are indicated.

Se estima que cada familia campesina en China sufre de escasez de combustible durante un promedio de tres meses por año. Para ayudar a remediar esta situación, se ha construido un total de 7.140.000 pequeños digestores de biogás en áreas rurales. En la provincia de Sichuan, 20.000 de esos digestores son de gran tamaño, pudiendo hacer funcionar máquinas diesel y generar electricidad. El modelo básico es uno construido para uso individual en hogares. Se emplea en esos digestores un 10% de excrementos humanos, un 40% de excrementos porcinos y vacunos, además de tallos de plantas y un 50% de agua. El valor calórico de la materia orgánica llevada a fermentación es en un 80% mayor que si ésta fuera quemada. En vista de que en China se puede disponer de 1.400.000 millones de toneladas de excrementos por año, es obvio que éstos constituyen una fuente de energía abundante y barata. Además, el uso de digestores reduce en 95% los gérmenes y parásitos que contienen las heces. En un pueblo rural, Dongxian, con 200 a 300 familias, la incidencia de enfermedades intestinales se redujo en un 80% después de la instalación de los digestores. Se indican posibles vías de investigación para mejorar los digestores.

474/81 FAMILY AND COMMUNITY BIOGAS PLANTS IN RURAL INDIA. R. Roy (Alternative Technology Group, Faculty of Technology, The Open University, Milton Keynes MK7 6AA (UK)). Appropriate Technology, vol. 8, no. 1, p. 17-20 (1981).

This article begins by comparing the results of the operation of family biogas plants with community plants which are drawn from a pilot scheme developed by the Planning Research and Action Division of the Planning Department of the Government of Uttar Pradesh, India, in the village of Fatehsingh-ka-Purwa. The scheme includes two digesters of the Khadi and Village Industries Commission (KVIC) design, a distribution pipeline connecting each of the 27 village households to the gas supply, a 4.5-kW biogas diesel generator and a 5.2-kW biogas-diesel engine available for pumping water, cutting chaff and milling flour. The experience indicates that well installed community biogas plants operated by trained personnel can function well in an Indian village. Whether such plants can succeed economically and socially, as well as technically, is still very uncertain. The adoption of a fixed gas-holder type biogas plant appears to be worth considering in view of the economic improvement which it would make in the scheme. Factionalism in Indian rural society is seen as a powerful barrier to the co-operative spirit required for a communal scheme to succeed. The organization, operation and management of the system are described. Economic, social and technical aspects of the results obtained thus far are examined. 7 refs.

475/81 A SYSTEM FOR THE UTILIZATION OF AGRICULTURAL WASTES IN AN AGRO-INDUSTRIAL SETTLEMENT-KIBBUTZ AS A MODEL. I. Roussear, G. Shelef and U. Marchaim (Technion - Israel Institute of Technology, Haifa (Israel)). Resource Recovery and Conservation, vol. 4, p. 159-68 (1979).

This article describes the energy potential of agricultural wastes in Israel. A scheme for utilizing agricultural, domestic and agro-industrial wastes in a kibbutz is presented. The possibility of supplying the energy needs of a kibbutz of 1000 persons using biogas is considered. 25 refs.

476/81 ENHANCED ENERGY PRODUCTION AND WATER REUSE FOR SWINE OPERATION IN HAWAII. P.Y. Yang, C.J. Huang and H.M. Gitlin (University of Hawaii, Manoa, Honolulu (USA)). American Society of Agricultural Engineers Technical Paper 19 (1979). (From ASAE and Canadian Society of Agricultural Engineering Summer Meeting (held Winnipeg, Canada, 24 June 1979)). American Society of Agricultural Engineers, USA.

Enhancement of biogas production by enrichment of algae grown from anaerobic digestion of swine manure is feasible. An addition of 30% algal total volatile solids in the feed will increase gas yield by 17% compared to the conventional anaerobic digestion process without algal addition. A concentration of NH_3-N of 80-100 mg/l will provide the maximum specific-growth rate of algal growth which can be further digested to methane gas.

477/81 A SIMPLE STIRRER FOR A BIOGAS PLANT. S. Rajpakse (Industrial Development Board of Ceylon, 615 Galle Road, Katubedda, Moratuwa (Sri Lanka)). Biogas Newsletter Nepal, no. 11, p. 2 (1980).

Stirrers for biogas plants are deemed necessary by some but are considered by others to be an added complication and expense. This article describes a simple inexpensive design of a stirrer for a fixed-dome digester which is not fed with long stalks or grass. Consisting of bamboo or wood, foam-rubber and nylon cord, this stirrer can be installed locally.

D. WIND ENERGY

478/81 HYBRID WIND TURBINE SUITABLE FOR DEVELOPING REGIONS. E. Bilgen, I. Paraschivoiu and M. Kaine (Ecole Polytechnique, Montreal, Quebec (Canada)). Vol. 2, p. 4.3.3.1-4.3.3.6 of Renewable Alternatives (Proceedings of the Fourth Annual Conference of the Solar Energy Society of Canada, Inc., held London, Canada, 20 Aug. 1978). Solar Energy Society of Canada, Inc., Winnipeg, Manitoba, Canada (1978).

In this article, a study is presented of a hybrid wind turbine which consists of two vertical-axis coaxial turbines, one of Savonius type and the other a screw type. The Savonius-type turbine rotates in a uniform velocity field while the second, the screw type, converts the kinetic energy of the vortex flow generated in the centre of the first turbine. Theoretically, it was shown earlier that the total efficiency of such a hybrid wind turbine can have a higher efficiency compared to that obtained from a simple system and the simplicity of the Savonius for manufacturing and maintenance of the system is retained. A model has been built to study the overall performance of this system, the results of which will serve to design and build a prototype hybrid turbine for the northern regions of Quebec, Canada.

479/81 THE SAVONIUS ROTOR - PERFORMANCE AND FLOW. C.N. Jones, R.D. Littler and B.L. Manser (University of Exeter, Exeter (UK)). P. 102-8 of Proceedings of the First British Wind Energy Association Wind Energy Workshop (held April 1979).

Based on comparative tests of model rotors conducted at constant Reynolds number, it is concluded that a plain S-rotor has a performance equal to, or better than, the conventional Savonius rotor with an inter-vane gap. Comparative particle-flow visualization studies using these rotors, and a rotor with separated vanes, in a water channel, have indicated the importance of attached flow around the convex surfaces of the vanes, the doubtful value of the conventional gap, and the importance of vane shape. 7 refs.

480/81 PROSPECTS OF IMPROVING WIND-PUMP PERFORMANCE BY LOAD MATCHING. S.P. Govinda Raju (Indian Institute of Science, Bangalore (India)) and R. Ganesh Rajagopalan. P. 443-7 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Simple wind-pumps, often used in rural areas, consist of a wind rotor directly coupled to a positive-displacement water pump through a crank and transmission rod. Such wind-pumps have a poor system efficiency attributable in part to the mismatch between the torque-speed characteristics of the wind rotor and the pump. The performance gains that can be achieved by improving the matching between the rotor and the pump by suitably varying the pump displacement with rotor speed are analysed. Some details of this analysis and a hardware option (under study at this time) to achieve load-matching are presented.

481/81 HOW TO MAKE FERTILIZER FROM WIND, AIR, AND WATER. M. Dubey (Lockheed-California Co., Burbank, CA (USA)). Vol. 3, p. 62-7 of Proceedings of the Greater Los Angeles Area Energy Symposium (held Los Angeles, CA, USA, 26 Apr. 1977). J.W. Robinson (ed.), Western Periodicals Co., North Hollywood, CA, USA (1977).

Nitrogenous fertilizers, such as ammonia and ammonium nitrate, can be made from wind, air and water. These three ingredients are abundant, replenishable sources of energy and the basic chemical feedstocks for the process. The synthesis of ammonia, as it is made today, uses natural gas as the primary feedstock. The growing shortage of natural gas has caused much concern, for its future supply is uncertain, and the resulting price increases for ammonia-based fertilizers are forcing the prices of food higher and higher. The wind powered process suggested here is an attractive alternative.

E. ENERGY STORAGE

482/81 STORAGE OF HEAT. A SURVEY OF EFFORTS AND POSSIBILITIES. Swedish Council for Building Research (Stockholm (Sweden)). PB-295936 (1979) 162p. NTIS. US$16.50.

This presentation describes various methods for storing heat and is an attempt to produce a survey of the state-of-the-art in the field. Topic areas discussed include the following: the role of heat storage in different energy systems; heat storage with passive and active solar-heat systems; sensible heat; latent-heat phase change; thermochemical reactions; and the US programme for storage of heat.

483/81 THERMAL ENERGY STORAGE AND MATERIALS FOR THERMAL ENERGY STORAGE. Kamimoto M., Sakuta K., and Sakamoto R. (Electrotechnical Laboratory, Ibaragi (Japan)). ETL Sākyurā (Circular of the Electrotechnical Laboratory), no. 196. 193p. In Japanese.

This document reviews the present state of research and development on materials for the storage of sensible and latent heat and of chemical energy. Several properties of thermal-energy storage materials are presented. The heats of dilution, vapour pressures and solubility of two promising pairs of liquid solutions are examined. Examples of thermal-energy storage using H_2SO_4-H_2O are given. Methods for calculating phase diagrams from thermodynamic data and vice versa are presented.

484/81 PHYSICAL AND CHEMICAL PROPERTIES OF LATENT HEAT STORAGE MATERIALS. D. Heine, F. Heess and M. Groll (Institute of Nuclear Energetic and Energy Systems, University of Stuttgart, Stuttgart (Fed. Rep. of Germany)). P. 536-45 of New Ways to Save Energy (Proceedings of the International Symposium, held Brussels, Belgium, 1979). Reidel Publishing, Dordrecht, Netherlands (1980).

This paper describes the results of an experimental study on the long-term thermal-storage behaviour of latent-heat materials and designs to be used in the temperature ranges between 200-450 °C and 700-900 °C. Studies on corrosion and thermal stability are included. 4 refs.

485/81 APPLICATIONS OF SOLAR ENERGY STORAGE SYSTEMS. J.P. Manzo (California State University, San Luis Obispo, CA (USA)). Specifying Engineer, vol. 41, no. 4, p. 106-11 (Apr. 1979).

This article discusses practical applications, cost considerations, and compares existing manufactured storage systems. It also contains actual prescriptive and performance specifications for the three major types of storage systems. The 3 systems considered are: liquid storage tank, dual-medium thermal-storage bed; and thermochemical storage tank. Sample prescriptive and performance specifications for each type are given. "Short-time" storage, to meet loads for periods of a few days or less, has been shown to be the most economical in building applications. For some heating, long-term storage appears economically impractical. In some operations, the storage unit should be located within the space to which heat is being added. In this way, "losses" from the storage unit to the surroundings are not losses, but are heat energy transfers from storage to the space to be heated. 9 refs.

F. SOCIO-ECONOMIC ASPECTS

486/81 FUELLING CONTROVERSY. R. Shirkie. The IDRC Reports, vol. 10, no. 2, p. 17-9 (1981).

With the increase of petroleum prices, the most attractive alternative is probably alcohol fuels produced from plant sources. With the appeal of alcohol fuels becoming irresistible, the prospect of energy independence for oil-deficit nations through agriculture is clouded by the competing priority for agriculture: food production for an ever-increasing population. Any significant production of alcohol fuels in the food-surplus industrialized countries is likely to displace food exports and result in increased food prices. However, perhaps by attempting to find a proper balance between food and fuel production, energy self-sufficiency, economic stimulation and ultimately increased agricultural production could result. Although initially thought to be a net energy consumer, alcohol production from sugarcane, maize and sweet sorghum is now seen to have a favourable energy balance if crop waste, solar energy or even coal rather than petroleum are used to process the alcohol and provide the needed fertilizer. Brazil appears to be one country that is mastering the economics of alcohol fuel from sugarcane to some extent from cassava. Thailand, when under pressure to restrict trade in cassava with Europe, may begin considering an alcohol programme to stabilize the domestic prices and small-farmers' incomes from cassava. For countries like USA and Canada, however, should production emphasis shift towards fuel rather than food, the amount of food available on the world market for food-deficit nations could be markedly reduced, until the resulting increased food prices make the division between energy and food production a function of the relative prices of the products. Furthermore, it is in the competition for land, water, fertilizer and credit that the conflict could become serious. Ways of reducing or avoiding the conflict include increasing agricultural yields, providing fuel crops on marginal land and the development of new technologies and processes that convert the cellulosic material of plants into alcohol. Work in Canada at the University of Waterloo involves the combining of the cellulose-converting genes of certain bacteria with the fermenting genes of yeast to produce organisms that will simplify alcohol production and expand its potential feed stock to nearly all plant materials. Some experts feel, therefore, that what is needed are carefully worked out policies and plans with good management to carry out an alcohol fuel programme closely co-ordinated between the industrial, agricultural, energy and transportation sectors.

487/81 ENERGY AND AID. The OECD Observer, no. 111, p. 23-6 (1981).

Increased energy production has become a key priority for the oil-importing developing countries: their economies are expanding and modernizing while their oil bills have shot up from US$30 billion in 1978 to nearly US$80 billion in 1981 (two-thirds of it for the newly industrializing countries). Investment, planning, training and research needs are enormous. The World Bank, which is now exploring the possibility of setting up an agency to develop energy production in the Third World, puts the annual investment needed between now and 1985 at around US$40 million (twice the annual figure of the last five years) with an acceleration for the period beyond. The developing countries depend on outside help in this task. In providing external support to the energy sector of Third-World countries, bilateral and multilateral donors are guided by the development priorities set by these countries themselves. While much of the aid to the energy sector provided by members of the OECD Development Assistance Committee is channelled through the multilateral institutions, their bilateral contributions are the main source of aid support. These bilateral contributions - together with non-concessionary financial support - are analysed in an OECD Secretariat report submitted to the UN Conference on New and Renewable Sources of Energy. The article outlines the contents and briefly describes, by way of illustration, recent action taken by five countries: France, Fed. Rep. of Germany, Japan, the Netherlands and the USA.

488/81 ENVIRONMENTAL ASSESSMENT OF STILLAGE CONTROL. W.K. Barney and H. Chang (Argonne National Laboratory, Argonne, IL (USA)). Paper presented at the Second US Department of Energy Environmental Control Symposium (held Reston, VA, USA, 17-19 Mar. 1980) 1980. 12p. NTIS. US$7.50.

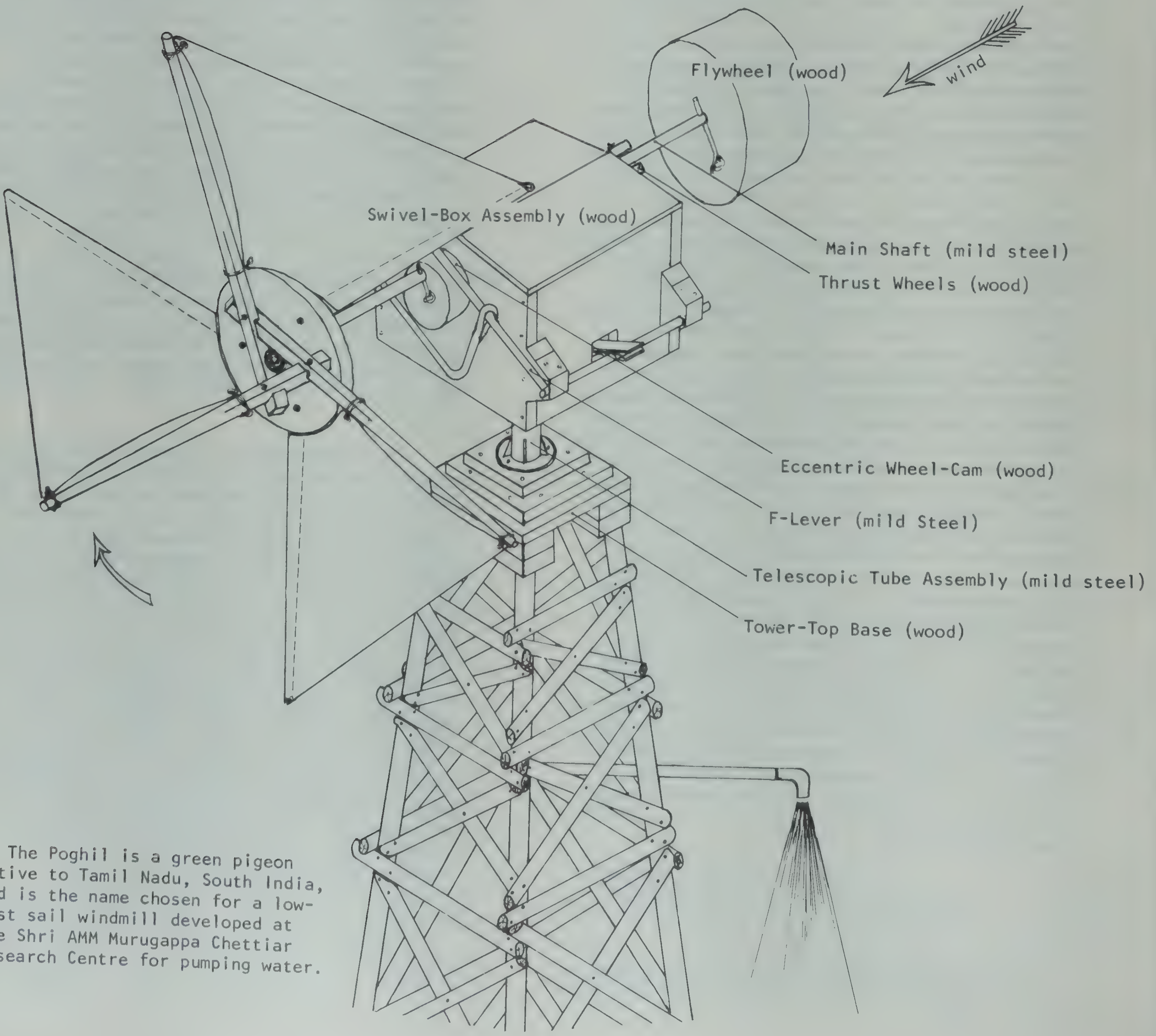
The US government is encouraging increased production and use of gasohol in an effort to make the United States more energy independent. The current national goal is to substitute gasohol for 10% of the unleaded gasoline consumed in the United States by the end of 1980. Increased production of fuel ethanol in the years to come seems certain. In producing fuel ethanol (100%) from biomass feedstocks by fermentation, a liquid residue called stillage is produced. The concentration of BOD_5 in stillage is usually high compared to that in domestic waste, and this residue must go through a waste-treatment process before being discharged to the environment. This paper identifies the types of stillage that are produced as well as their control. The concept of stillage control in the context of this paper includes both the uses and environmental-control technology needs of stillage.

SELECTED ARTICLE - I

This article was prepared by Dr. F. S. Myers from the text and illustrations of Poghil, a 55-page English-language version of a manual to guide villagers and artisans in the step-by-step construction, operation and maintenance of the Poghil windmill. The manual is being translated into Tamil and Hindi. The United Nations University has encouraged the propagation of this device through a project involving the development and establishment of an integrated rural food and energy system in Tamil Nadu, India.

POGHIL

V. Geethaguru
Photosynthesis and Energy Division
Shri AMM Murugappa Chettiar Research Centre
Tharamani, Madras 600042, India


Flywheel (wood)
wind
Swivel-Box Assembly (wood)
Main Shaft (mild steel)
Thrust Wheels (wood)
Eccentric Wheel-Cam (wood)
F-Lever (mild Steel)
Telescopic Tube Assembly (mild steel)
Tower-Top Base (wood)

The Poghil is a green pigeon native to Tamil Nadu, South India, and is the name chosen for a low-cost sail windmill developed at the Shri AMM Murugappa Chettiar Research Centre for pumping water.

The Poghil project involves not only the technology of the windmill itself, but an effort to disseminate the technology of which a handbook of clarity and detail is a part. Twenty of these windmills have been placed in service in the past two years.

The windmill was designed and developed especially to serve rural needs. Therefore, it is low-cost, easily constructed and maintained by villagers and uses locally available material. These criteria are considered more important than efficiency. It can be used in mountainous, desert, coastal (and especially estuary) regions for such purposes as domestic and community water supply; small-scale forestry and agriculture; and for pumping the water used by marine shrimp and turtle hatcheries.

This windmill is usable in regions where the water table is less than 12 m below the surface. In the following table are listed the main technical details.

TECHNICAL DETAILS

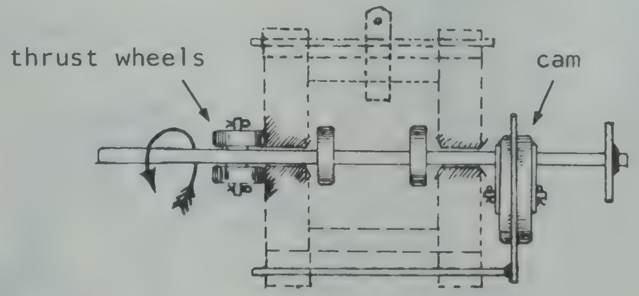
1.	Sweeping circle	3.8 m
2.	Number of sails	3
3.	Solidity ratio	36.4
4.	Tip speed ratio	(a) 3.34 at 20 km/h (b) 2.51 at 15 km/h
5.	Tower height	6.0 m
6.	Cut-in-wind speed	10 km/h
7.	Rated wind speed	20 km/h
8.	Furling wind speed	45 km/h
9.	Pump	Reciprocating single action
	Diameter	64 mm
	Stroke	114 mm
10.	With pumping head of	9.0 m
11.	Discharge	1500 to 1750 liter/h (at 15-20 km/h)
12.	Cost	RS. 3000

It should be noted that cost in this table includes materials and labour, which involves about 70 man-days. The pay-back period has been estimated to be two years.

The remainder of this article is a description of some of the most important components of the windmill and an outline of its construction.

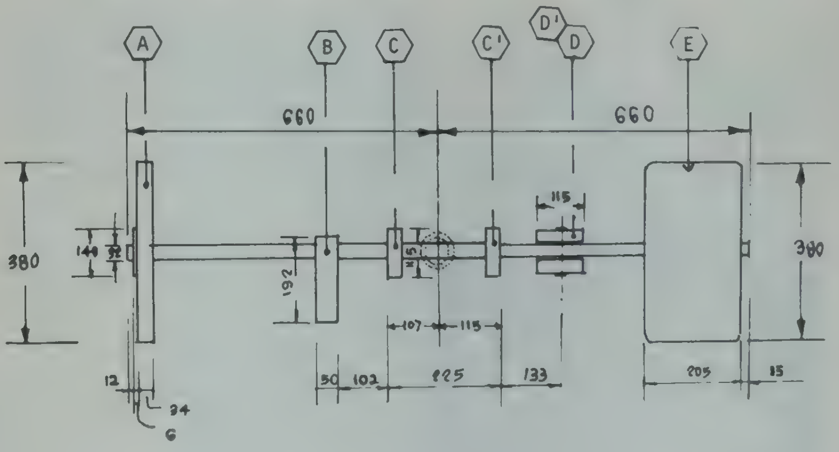
SWIVEL BOX AND SHAFT ASSEMBLY

A hard wooden cam is connected to the main shaft of steel using shear and cross pins. Wooden thrust wheels are also fitted to this shaft.



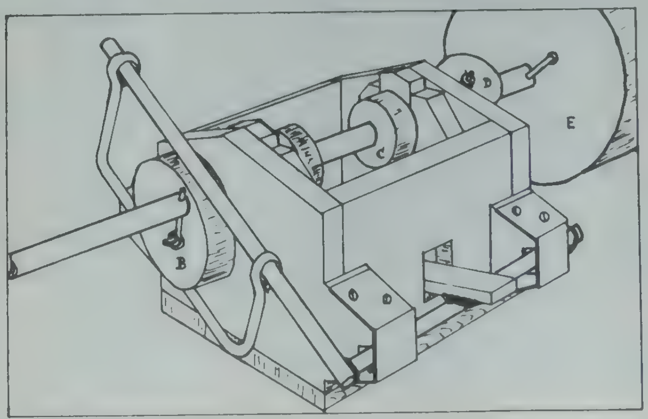
Shaft Assembly

These wooden thrust (planetary) wheels support the thrusting motion of the shaft due to load variations of the sails in changing winds. The shaft is supported by a swivel box which also supports or contains the cam, brakes, thrust wheels and 'F'-lever. This swivel-box assembly is unique in that there are no gears or bearings with most moving parts experiencing wood-to-wood contact.



(upper)

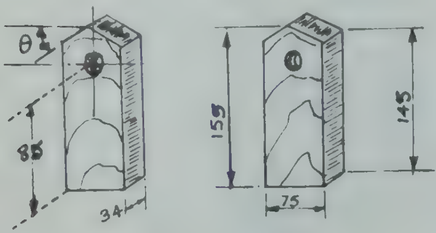
A rotor hub
B eccentric wheel
C,C' brake wheels
D,D' thrust wheels
E flywheel



(lower)

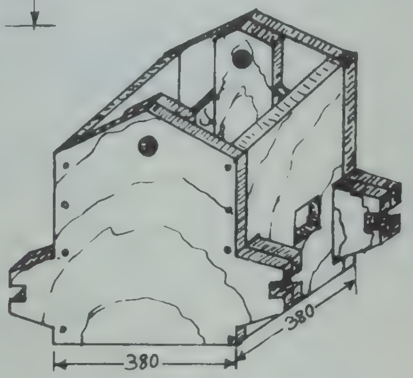
Main Shaft Assembly (upper)
Swivel Box and Shaft Assembly (lower)

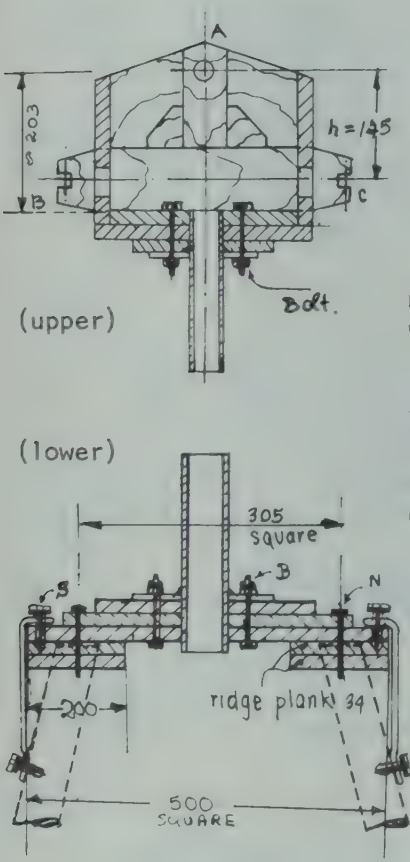
The holes in the swivel box and pillars act together as shaft bearings. The face of the box acts as the thrust-bearing surface. These surfaces and parts must be lubricated every 15 days.


θ
85
34
155
75
145

Pillar Bearings

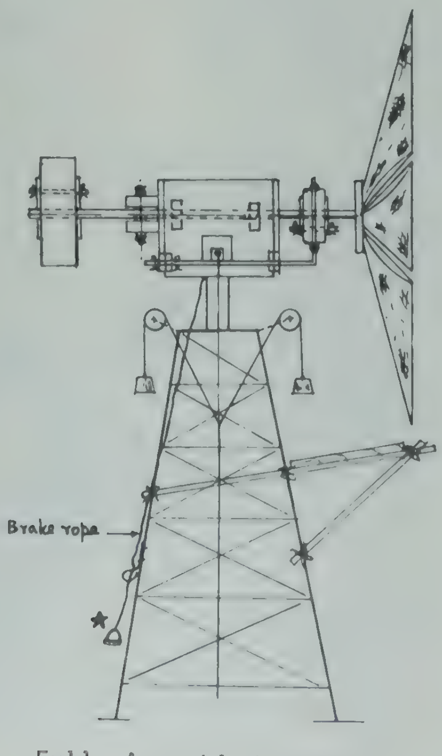
Swivel-Box Walls




A
ø203
h=135
B
C
Bolt.
(upper)
(lower)
305 square
B
S
N
ridge plank 34
200
500 SQUARE

Swivel-Box Assembly (upper)
Tower-Top Base (lower)

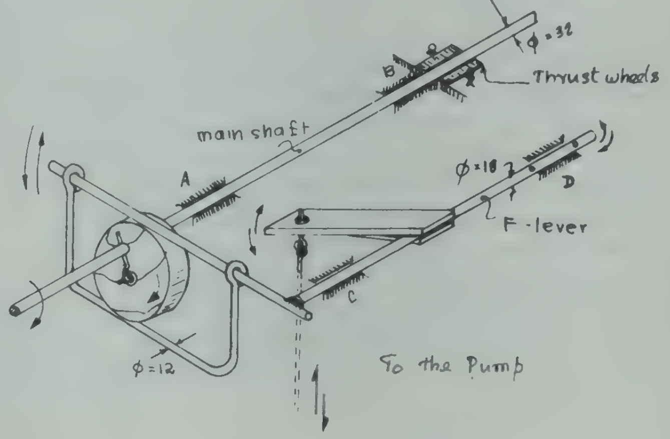
Two thick-walled telescopic mild-steel tubes, one within the other, make possible the swivelling of the rotor at the tower top. The swivel box is connected to the inner pipe and the swivel-box base is connected to the outer one.

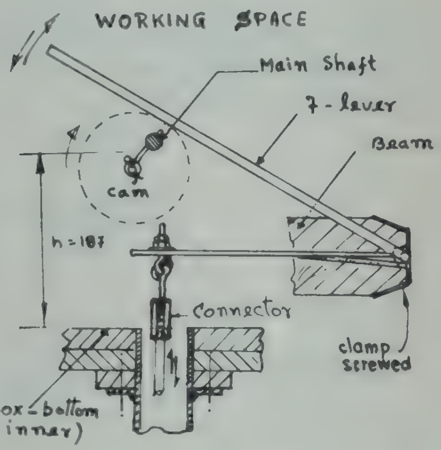


Fully Assembled Windmill

THE TRANSMISSION ASSEMBLY

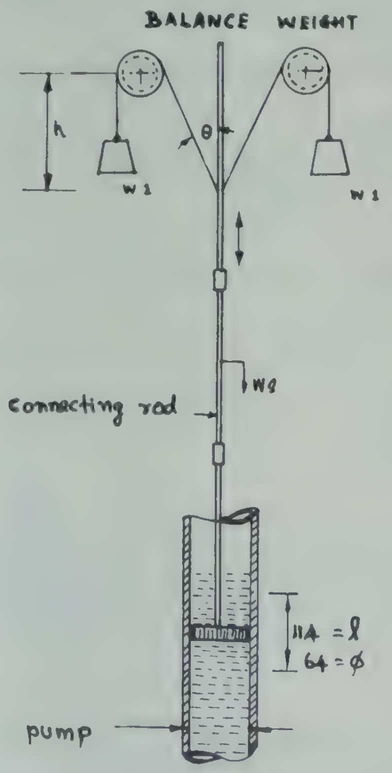
As the shaft and cam rotate together, the cam causes the 'F' assembly to move up and down. It is this action that moves the piston of the pump.


ϕ=32
B
Thrust wheels
main shaft
A
ϕ=18
D
F-lever
C
C
ϕ=12
To the Pump


WORKING SPACE
Main Shaft
F-lever
Beam
cam
h=187
Connector
clamp screwed
Box-bottom (inner)

Two Views of the Transmission ('F' Assembly)

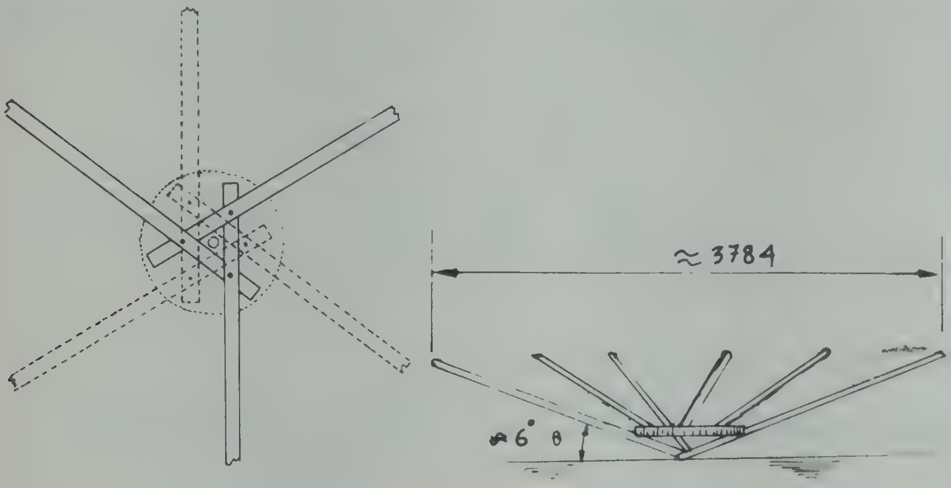
A counter balance assembly is constructed of two weights, pulleys and rope which is attached to the connecting rod. This is done to offset the weight of the connecting rod, thus reducing the load on the windmill.

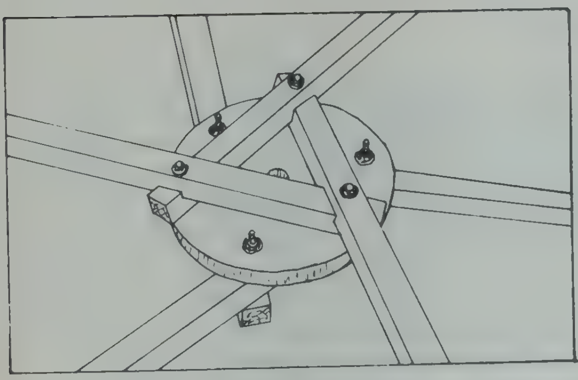

BALANCE WEIGHT
h
θ
W1
W1
W2
Connecting rod
114 = l
64 = ϕ
pump

Connecting Rod Assembly

THE SAIL ASSEMBLY

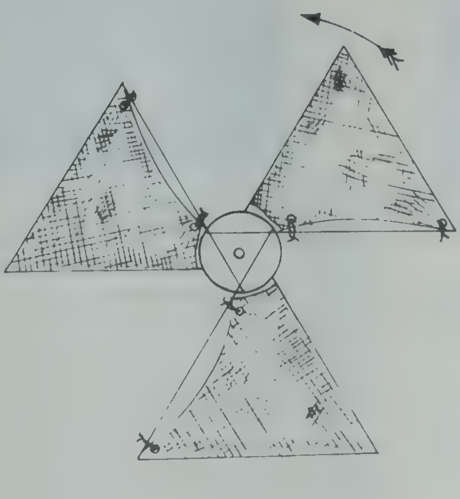
The sail assembly uses six wooden spokes. These are carefully selected to be tough and seasoned. Each spoke is square at the base and tapered at the top. They are arranged with three on each side of a wooden hub in an overlapping pattern in the shape of an equilateral triangle. This overlapping causes the blades to be inclined to the rotor-hub face, thus helping the rotor to orient itself in the direction of the prevailing wind.





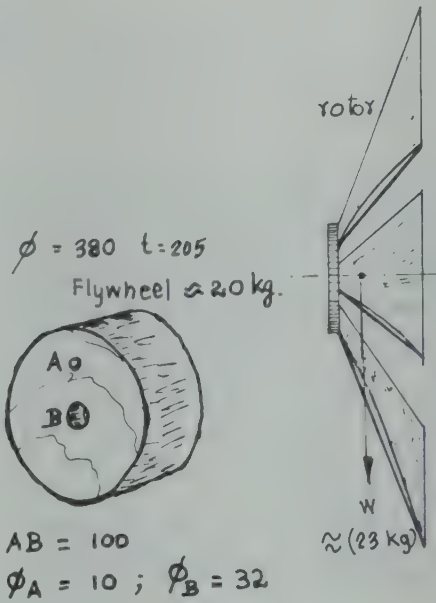
Spokes and Hub Assembly

A set of three cloth sails of triangular shape are stitched. The folded sheath is attached to the leading spoke and the eyelets are fastened to the trailing spoke. By this method the sail will break free at the determined wind speed, thus protecting the windmill from gusts and gales.



Rotor (looking into the wind)

A 20-kg flywheel is constructed to act as a counterbalance to the sail assembly and to help maintain angular inertia.



Flywheel

Photograph of Poghil

SELECTED ARTICLE - II

This article written by F.S. Myers is based on information provided by Mario Chanco of the Earthman Society, P.O. Box 3427, Manila, which is active in this field in the Philippines.

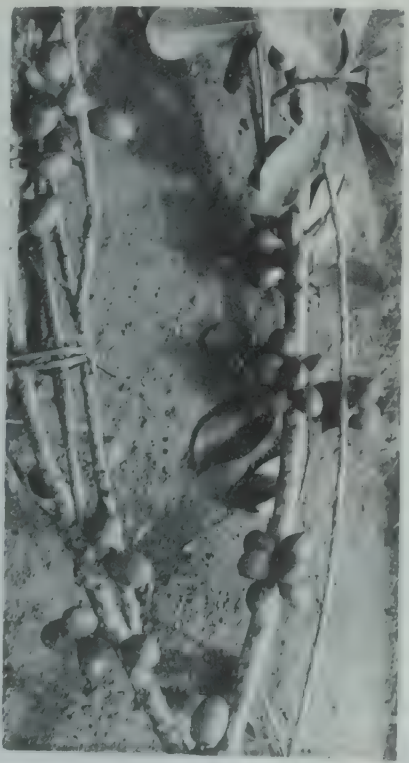
THE PETROLEUM NUT: A POTENTIAL INDIGENOUS SOURCE OF FUEL FOR THE PHILIPPINES

Recently, the value of the petroleum nut (Pittosporum resiniferum) was re-discovered in the Philippines. It has been used in various locations throughout the country at different times as an aphrodisiac, a treatment for bronchitis, a skin ointment, a general antidote and a fuel for small lamps. Only now, in the context of the current search for biological products which can serve as fuel for machines, has the source been considered as a possible major asset. The fruit of this species have acquired the name, petroleum nut, in the Philippines because the oil from the fruit has an odour resembling that of petroleum and because even the fresh green fruit will burn brilliantly when subjected to a flame. This article will consider two related topics: 1) the petroleum nut itself and 2) the way the Philippines is approaching the development and use of this energy resource in particular and other biological resources in general.

The Petroleum Nut

It has been estimated that five of these trees around a home could annually produce 300 liters of fuel which could be used domestically. Larger quantities could be used for small motors required by agriculture and industry, especially in the rural areas.

Pittosporum resiniferum is a tree that can grow as high as 25 to 30 meters and sometimes bears fruit when only 6-12 meters in height. The tree is not particularly abundant in any special part of the country but can be found widely in thickets and second-growth forests on high mountain ridges. The fruit is about 3-5 cm long and contains numerous small seeds. A single tree can bear 15 kg of fruit which yields 873 liters of oil through a combination of compression and distillation. It has also been noted that all parts of the tree are resiniferous. A chemical analysis of the oil reported in 1909 showed that it contains a dihydroterpene ($C_{10}H_{18}$), as well as considerable quantities of normal heptane. In general, the liquid product of the nut contains 20% hydrocarbons and 16% alcohol (with an octane rating of 75-80). The chemical characteristics of the nut vary seasonally and with the degree of ripeness of the fruit. The following table gives specific information obtained from a fractional-distillation analysis of the oil.



The Petroleum Nut

Fractional Distillation of Petroleum Nut Oil

	Fraction (°C)	Yield (g)	Spec. grav.	Probable product
1	98 - 103	41	1.3898	heptane
2	103 - 110	18	-	-
3	110 - 120	21	-	-
4	120 - 140	12	-	-
5	140 - 150	7	-	-
6	150 - 155	47	-	-
7	155 - 160	49	1.4630	substance with turpentine-like odour
	> 165		decomposes to give a resinous oil	

Development of the Nut

Recognizing that the petroleum nut has great potential as an energy source, the Philippine government has taken steps to develop the tree throughout the country. All of the governments 43 agricultural stations are planting the tree and producing seedlings. Governmental agencies are also studying the tree for possible environmental and health effects. In fact, one such agency is being created to oversee its development. In addition, there are private groups that are interested in the petroleum nut as well as other biological sources of fuel, medicines and other products. Both sectors hope to locate, classify and propagate potentially important species. The production of the petroleum nut, in particular, is a type of project in which all levels of society can participate since it can be grown and used around residences as well as on large plantations.

Some groups are very interested in finding, identifying and developing important biological sources and are training and sending many people out into the countryside to help realize the country's full biological potential. This is being done not only for the protection of the valuable resources that nature has evolved over many years, but also for the immediate use of valuable products and for guaranteeing a suitable long-range energy supply. By being aware of their own biological resources and by advancing the know how to fully develop them, the Philippines is less likely to become dependent in the future on foreign sources of energy and technology.

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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ASSET 3/9

Abstracts of Selected Solar Energy Technology

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太阳能 SOLAR ENERGY СОЛНЕЧНАЯ ЭНЕРГИЯ सौर ऊर्जा ENERGÍA SOLAR সৌর শক্তি
SONNENENERGIE ENERGIA SOLAR الطاقة الشمسية 太陽エネルギー ENERGI MATAHARI
ÉNERGIE SOLAIRE सूर्य शक्ति ENERGIA SOLARE شمسی توانائی DAYANING SURYA 태양에너지
ஞாயிற்றியலான ஆற்றல் సూర్య శక్తి دھوپ دی طاقت GÜNEŞ ENERJİSİ СОНЯЧНА ЕНЕРГІЯ
NĂNG LƯỢNG MẶT TRỜI ENERGIA SŁONECZNA સૂર્ય શક્તિ СОЛАРНА ЕНЕРГИЈА ಸೂರ್ಯ ಶಕ್ತಿ
انرژی خورشیدی സൂര്യോർജ്ജം KARFIN HASKEN RANA ସୂର୍ଯ୍ୟ ଶକ୍ତି NISHATI YA JUA နေစွမ်းအင်
พลังงานแสงอาทิตย์ ENERHIYA NG ARAW ENERGIE SOLARÄ SOLENERGI ZONNE ENERGIE
ਸੂਰਜ ਦੀ ਸ਼ਕਤੀ دلمر انرژی SLUNEČNÍ ENERGIE ÉNESI PANON POÉ قوتِ سورج NAPENERGIA
TENAGA SURIA AGBARA ŌRUN SEMBE DIGA NAANGE IKE ANYANWU ພະລັງ ງານ ແສງອາທິດ
AMANDLA ELANGA සූර්ය රශ්මි බලය ҚУЁН ЭНЕРГИЯСИ گئون انرژیسی ΗΛΕΙΑΚΗ ΕΝΕΡΓΕΙΑ
ENERHIYA SA ADLAW سج جي قوتُ የፀሐይ ፡ ኀይል СЛЪНЧЕВА ЕНЕРГИЯ SUNČANA ENERGIJA
ENÈGI SOLÈY ሁምና ፡ አዱ ថាមពល ព្រះអាទិត្យ KOWADDA PANASSA AREH HERIN'NY MASOANDRO
INTI KALLPA UMULIRO W'IZUBA ཉི་མའི་ནུས་པ། ҚУН ЭНЕРГИЯСЫ OWIA AHOƆDEN DAI5YAŊ2 NƏŊ2
AURINKOENERGIA ENERHIA ITI INIT TIYA I NTANGU ENERGI DEL SOLELH SLNEČNA ENERGIA
TABARTA QORAXDA ĶUYAX ENERGIYISI ENERGJI DIELLORE ՍՈԼԱՐ ԷՆԵՐԳԻԱ
КҮНӘШ ЕНЕРКИЈАСЫ მზის ენერგია HXO BBU WE ENERHIYA SANG ADLAW NGUYA YA MOYI
TANAGO MATOARI সিং চাঙো ডাক ናይፀሐይ ፡ ኀይሊ PAYU MATAN-AI روچ تاب KILE BARKA
ENERHIA HALI SA ALDAW AWATANGENNA MATANNA ESSOE ODUDU UTIN ŊDO ZAZA
AMAANYI GA ENJUBA אנרגית השמש DONO KAUSU BE آفتابک قوتّ هیزی هه تاوی
HINYA WA RIUA SAULĖS ENERGIJA BUKOLE BWA MUNYA UTAÑA UÁTUA TAIYANG NENG
NGUYA EA WANE WĨNTOOG TƱƱLEM MPHAMVU YA DZUWA SIMBA RE ZUWA
MATLA A LETSATSI CUARAJHY MBARETÉ KATAN U JANTE BI

THE UNITED NATIONS UNIVERSITY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

Unless otherwise explicitly stated, the views expressed in the abstracts and articles contained herein are not necessarily those of the United Nations University.

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Recipients are encouraged to provide **ASSET** with copies of their publications concerning the technological and socio-economic aspects of solar, bioconversion and wind energy utilization for abstracting in future issues.

THE UNITED NATIONS UNIVERSITY
Printed in Japan 1981

INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy
  B1 Radiation Measurement
  B2 Photovoltaic Conversion
  B3 Active Thermal Systems
  B4 Passive Thermal Systems

C. Bioconversion Energy
  C1 Biomass Production and Conversion
  C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Scientists and engineers in developing countries who wish to participate in this information network and receive ASSET regularly may do so free of charge. ASSET is available in industrialized nations at an annual subscription rate of US$25 by sea mail and US$40 by air mail payable by check, money order, bank draft or UNESCO book coupons to the United Nations University. ASSET has published lists of the names and addresses of all members of the network as of 1 December 1980 in vol. 1, no. 12 (1979) and vol. 2, no. 10 (1980).

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

489/81 INTEGRATED RURAL ENERGY PLAN: A CASE STUDY OF A TYPICAL VILLAGE IN KUTCH DISTRICT OF GUJARAT STATE. K.S. Rao, K.K. Bokil and S.S. Soin (Central Salt and Marine Chemicals Research Institute, Bhavnagar (India)). P. 351-9 of Proceedings of the National Solar Energy Convention of the Solar Energy Society of India (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

Energizing villages in semi-arid and underdeveloped regions (like Kutch, India) by conventional methods is technically feasible, but is also very capital-intensive and may take a long time. A study was made to explore the possibility of using locally available materials to meet the energy requirements of such villages. The requirements for irrigation, lighting, water, cooking, and a few village industries were determined. A crop pattern was proposed for both the Khariff and Rabi seasons to make the village self-sufficient in terms of food grains for people and fodder for cattle. The village resource potentials for solar, wind, and biogas energy systems were estimated.

490/81 CONCEPTUAL DEVELOPMENT OF A SOLAR TOWN IN IRAN. M.N. Bahadori (University of Shiraz, Shiraz (Iran)). P. 715-56 of Solar Energy Conversion: An Introductory Course. A.E. Dixon, J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

Solar and wind energy, sky radiation, daily temperature fluctuations, city organic wastes and waste water, and energy plants may be employed to meet all the energy needs of a purely residential town. The energy requirements of a town of 4000 inhabitants are estimated. No major change in people's life style, except for low-temperature cooking by steam, is introduced. Several methods for solar energy utilization are considered: central generation of electricity, hot and chilled water, and steam (for cooking); local generation of electricity, hot and chilled water, and steam along with the central utilization of city wastes to produce methane gas for high-temperature cooking; central utilization of wastes and the growth of plants for their energy values; and a system involving the suitable design of buildings to be heated and cooled by solar energy and other natural resources along with both central generation of electricity and methane and local generation of hot and chilled water and steam.

491/81 ENGINEERING CONSIDERATIONS IN IMPLEMENTATION OF NOVEL ENERGY CONCEPTS. C. Pritchard (Department of Chemical Engineering, University of Edinburgh, Edinburgh (UK)). P. 398-401 of Future Energy Concepts. IEE Conference Publication No. 171. Institution of Electrical Engineers, London, UK (1979).

The use of renewable energy resources in the Scottish Highlands and the Sahara is discussed. In the Highlands, many scattered low-density communities are without a centralized electricity supply system, and the provision of small hydropower units at old water mills, coupled with wind power from vertical-axis wind turbines, is advocated (40% of the wind energy occurs in only 7% of a period due to gusting conditions). In the Sahara, flat-plate collectors generate electricity via the Carnot cycle using butane under pressure as the working fluid and well water for cooling. The water is later used for irrigation, and some 30 stations (up to 50 kW) are currently operational. 6 refs.

492/81 HOUSEHOLD ENERGY USE IN NON-OPEC DEVELOPING COUNTRIES. J.C. Fernandez (US Department of Energy, Washington, DC (USA)). RAND-R-2515 DOE (1980). Rand Corp., Santa Monica, CA, USA. 92p.

This report analyses the energy consumption and distribution according to types in the domestic sector of the following countries: Brazil, Guatemala, India, Malaysia, Mexico, Pakistan, Republic of Korea and Sudan.

493/81 TECHNOLOGY ASSESSMENT: THE CASE OF THE DIRECT USE OF SOLAR ENERGY. N. Georgescu-Roegen. Atlantic Economic Journal, vol. 6, p. 15-21 (1978).

A review of the historical development of energy utilization is presented prior to an assessment of the technology involved in the direct use of solar energy. In this assessment, two thermodynamic concepts were utilized: that no mechanical work can be performed without the use of bulk matter, and that no closed system can perform mechanical work at a constant rate indefinitely. It was concluded that to collect and convert solar energy in outer space (where the intensity is greater) and then to transmit this energy to earth may be feasible but is less easily utilized than fossil fuels. 19 refs.

B. SOLAR ENERGY

494/81 SOLAR ENERGY UTILIZATION. T. Michels. Van Nostrand Reinhold Co., New York, NY, USA (1979) 267p.

Methods to weigh the costs and benefits of each type of system based on the specific situation (climate, type and size of dwelling, energy conservation options and other available energy, sources) and key data on how walls, windows, ceilings, attics, and floors can be adapted to maximize system efficiency are presented. Passive designs are discussed that incorporate aesthetically favourable features such as low-cost solar-heating systems. Real-life examples show how passive systems can supply 90 to 100% of the heating requirements of particular dwellings. Passive-design concepts such as the Trombe wall, roof ponds and drum walls are covered in easy-to-follow terms. Proven successful designs (the Hay house, the Wright house, the Davis house, and others) are described and evaluated in comprehensive detail so that the reader can draw on this experience to create similar systems. Coverage of active systems comprises both flat-plate and concentrator technologies. Active collection systems and principles are described and analysed using case studies. Collector components and their functions are addressed in terms of the pitfalls and the most appropriate use of materials for absorbers, cover-plates, insulation and casings. Air-type and water-type collectors and their dynamic relation to various thermal energy-storage options (water, rocks, and eutectic salts) are discussed in detail. Additional sections illustrate how to design passive and active systems based on the heating load, with significant attention devoted to storage dynamics, collector tilt, climate data and how to assess it, and system capabilities.

495/81 SOLAR ENERGY EXPERIENCE IN ISRAEL: A CASE STUDY. D. Wolfe and D.H. White (University of Arizona, Tucson, AZ (USA)). P. 83-110 of Proceedings of the Conference on Commercializing Solar Energy in Arizona (held Tempe, AZ, USA, 9 Nov. 1977). Arizona State University, Tempe, AZ, USA (1977).

The following topics are discussed: present applications of solar energy, local conditions and incentives, factors affecting the use of solar water heaters, the off-peak power status, psychological aspects, public acceptance, governmental and local regulations, problems with central water-heating systems, economics of solar energy systems, standardization of equipment, research and development, and repeating the Israel experience in Arizona, USA.

496/81 INDIAN SOLAR ENERGY RESOURCES INDEX, 1975-1979. Tata Energy Research Institute, Bombay, India (May 1980) 86p.

A bibliography of 746 references on major Indian solar energy resource papers is presented. The references are categorized according to the various solar energy disciplines. An author index is included.

497/81 SOLAR COOLING R AND D OVERVIEW. Brookhaven National Laboratory (Upton, NY (USA)). Proceedings of the Third Solar Heating and Cooling R & D Branch Contractors' Meeting (held Washington, DC, USA, 24 Sept. 1978). BNL-24924. NTIS. US$7.50.

The status of the principal solar energy conversion processes for cooling is reviewed, applications ready for demonstrations are identified and directions for the near-term research and development efforts needed to bring other potentially successful cooling systems to the point of demonstration are recommended. The principal solar cooling methods are classified as: absorption, heat-engine-vapour compression, desiccant, solar-assisted heat pump, photovoltaic heat pump, and passive systems.

498/81 CONCENTRATORS FOR SOLAR ENERGY UTILIZATION. G. Swarup and V. Ealasubramanian (Radio Astronomy Centre (TIFR), Ootacamund (India)). P.1.1-1.9 of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

A review of concentrating collectors for the photo-thermal utilization of solar energy is presented. Various types of non-tracking and tracking concentrators such as vee troughs, Fresnel lenses, Winston collectors, paraboloids, parabolic troughs, segmented-mirror troughs, central-tower heliostat arrays and spherical mirrors are described and their advantages and disadvantages enumerated. A short description is given of the recently proposed thermo-photovoltaic system using paraboloidal reflectors. The problems of heat transfer at the absorber, tracking requirements and energy storage are briefly discussed. Major experimental units under construction at different places are listed. Overall efficiency and cost effectiveness of solar-thermal systems are discussed and probable methods of improving the cost effectiveness are explored. The need to develop cheap concentrators is stressed. 29 refs.

499/81 SPECTRALLY SELECTIVE SOLAR ABSORBER COATINGS. M.G. Hutchins (University College, Cardiff, Wales (UK)). Applied Energy, vol. 5, p. 251-62 (1979).

A review is presented of the physical processes responsible for spectral selectivity in solar-absorber coatings. Examples of practical coatings which have found common usage in solar-heating systems are surveyed. The durability requirements of a coating are assessed and a summary of techniques of surface analysis is given.

500/81 USE OF THIN GLASS REFLECTORS FOR SOLAR CONCENTRATORS. R.H. Marion (Sandia Laboratory, Albuquerque, NM (USA)). Paper presented at the Solar Reflective Materials Workshop (held San Francisco, CA, USA, 12 Feb. 1980). SAND-80-0109C (1980) 12p. NTIS. US$7.50.

Elastically deforming thin glass (thickness of 0.13 to 0.80 mm) provides an alternate method of forming a curved glass reflector which can eliminate some of the disadvantages of thicker glass. A concept is described in which silvered thin glass is bonded to a steel backing to form a laminate with a reflectance greater than 93%. Subsequent bending of the flat reflector laminate to a concentrating profile produces compressive stresses throughout the glass if the laminate is properly designed. These compressive stresses enhance fracture resistance and the lamination provides protection for the silver. The design of the laminate is outlined for 0.25 and 0.51-mm thick glass and fabrication procedures are discussed. Thermal-humidity cycling, hail impact, bond-strength measurements and reflectance results are presented which demonstrate the performance capabilities of this reflector laminate concept.

501/81 LOW-COST SOLAR ANTIREFLECTION COATINGS. ANNUAL REPORT, 24 JULY 1978-24 SEPTEMBER 1979. R.J.H. Lin, J.C. Lee and P.B. Zimmer (Systems and Research Center, Honeywell, Inc., Minneapolis, MN (USA)). ALO-5300-T2 (Oct. 1979) 99p. NTIS. US$12.00.

Production processes for a low-cost organic anti-reflection (AR) coating and an etched AR coating on glass are being developed and improved. The etched AR-coating process has been scaled-up to etch full-size glass panes, but the chemical control of the etching solution remains a problem. Analytical methods including high-pressure liquid chromatography (HPLC), flame-excited atomic absorption, infrared spectroscopy, Coulter-counter techniques, and liquid index of refraction measurements were examined for application to this process monitor and control problem. A phenomenological model for the key reaction species in the etching process is presented along with a monitor control scheme using refractive-index measurements to set the initial reactant concentrations and HPLC to track in-process concentrations. The environmental durability of the organic AR coating of fused FEP-120 Teflon dispersion has been improved by the use of a hydrofluoric acid etch-silane coupling agent pretreatment. Improved coating processing techniques were developed culminating in the demonstration of scale-up feasibility for this process for glass panels up to 0.3 m x 0.3 m with good batch sample to sample repeatability.

502/81 SOLUTION GROWTH OF CdSe AND PbSe FILMS. R.C. Kainthla, D.K. Pandya and K.L. Chopra (Indian Institute of Technology, Delhi, New Delhi 110029 (India)). Journal of Electrochemical Society, vol. 127, p. 277-83 (1980).

Thin films of CdSe and PbSe were prepared using an immersion technique. The effects of different parameters on the speed of deposition and the thickness of the final layer were studied. A growth model for these films was developed and the structure of the films is presented. 11 refs.

503/81 A COMPARISON OF THERMAL PERFORMANCE OF AUSTENITIC STAINLESS STEEL SOLAR ABSORBER PLATES COLOURED BY CHEMICAL AND THERMAL OXIDATION TECHNIQUES. V.C. Sharma (Department of Physics, University of Benin, Benin City (Nigeria)). Energy, vol. 6, p. 133-8 (1981).

A comparison of the thermal performance of the chemically and thermally oxidized 18/8 Cr-Ni austenitic stainless-steel (SS) solar-absorber plates (light blue in colour) under bright sunshine conditions in Benin City, Nigeria, shows that the thermally oxidized austenitic stainless steel AISI 321 performs better than the chemically oxidized (SS) absorbing surface. The highest temperature recorded on a clear bright day, for a singly glazed thermally oxidized (SS) absorber plate, was 108 °C as against 102 °C for the chemically oxidized (SS) absorber plate under the identical conditions of plate masses and dimensions. 13 refs.

504/81 PHOTOGALVANIC CELLS. W.J. Albery and A.W. Foulds (Imperial College, London SW7 2AT (UK)). Journal of Photochemistry, vol. 10, p. 41-57 (1979).

The theory of solar photo-electrochemical cells and considerations of the kinetic characteristics of such systems are described. Two cases examined in detail are the Fe-Ru and Fe-thionine systems. 27 refs.

505/81 SAUR VIDYUT KOSH: THE SOLAR CELL. M. Sharon, S.G.Sharan, B.M. Prasad, A.P. Bholagir and R.R. Pradhananga (University of Poona, Maharashtra (India)). Vol. 2, p. 814-21 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.), Pergamon Press Elmsford, NY, USA (1978).

For the first time a fully solar galvanic cell has been developed which is reversible with solar radiation and has been named Saur Vidyut Kosh. The different types of photochemical reactions were studied and concentration cells were made. These cells can be charged by the sun within one hour and can be used for drawing current. The different types of cells are discussed. 15 refs.

B1. RADIATION MEASUREMENT

506/81 INFRARED RADIATION MEASUREMENTS. D. Anson (Lawrence Berkeley Laboratory, University of California, Berkeley, CA (USA)). P. 199-213 of Part A of Solar Energy Technology Handbook. Marcel Dekker, Inc., New York, NY, USA (1980).

Thermal and photon detectors of infrared radiation are considered and the characteristics of infrared radiometers are discussed. Approaches to eliminate undesirable signals from conductive and convective gains are described, including ventilating and shielding of the detector. Applications of infrared measurements are discussed. 25 refs.

B2. PHOTOVOLTAIC CONVERSION

507/81 SILICON SOLAR CELLS. I. BASICS. R.E. Thomas (Carleton University, Ottawa, Ontario (Canada)). P. 785-803 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

A review of the photovoltaic effect in semiconductors is presented. Basic solar-cell operation is described and terms which are regularly used to describe solar-cell quality are defined. The factors governing the theoretical performance limits for silicon solar cells are also discussed. 26 refs.

508/81 n-CdS/p-$ZnIn_2Se_4$ THIN FILM SOLAR CELL. F.J. Garcia and M.S. Tomar (Universidad Simón Bolivar, Caracas, 108 (Venezuela)). Thin Solid Films, vol. 69, p. 137-9 (1980).

The photovoltaic behaviour of a $CdS/ZnIn_2Se_4$ vacuum-evaporated thin-film solar cell is reported for the first time. Because of the band gap of $ZnIn_2Se_4$ (1.93 eV), this combination of semiconductor materials seems to be suitable for use as one of the junctions in tandem solar-cell configurations. Uncoated cells exhibited efficiencies of the order of 1.5% under an illumination of 100 mW/cm^2. 4 refs.

509/81 APPLICATION OF ELECTROCHEMICAL METHODS IN $Ga_{1-x}Al_xAs/GaAs$ SOLAR CELL FABRICATION. J. Przyluski, J. Mendyk and N. Druto (Institute of General Chemistry and Inorganic Technology, Technical University of Warsaw, Warsaw (Poland)). Solar Cells, vol. 3, p. 369-74 (1981).

A $Ga_{1-x}Al_xAs/GaAs$ $(x = 0.8)$ heterojunction model solar cell with an anti-reflection (AR) coating was produced by liquid-phase epitaxy followed by the formation of an AR coating using anodic oxidation and electrochemical plating for the contact fingers. The light source used had slightly different spectral characteristics from those of the solar radiation, and the light source also had a power density of 22 mW/cm^2. Under these conditions the device produced shows the following characteristics: $V_{oc} = 0.865$ V; $J_{sc} = 4.453$ mA/cm^2; $FF = 0.68$; and $\eta = 11.8\%$. It was shown that the low-cost electrochemical process may give satisfactory results in the production of devices for solar energy conversion. 4 refs.

510/81 HIGH-EFFICIENCY THIN-FILM GaAs SOLAR CELLS. R.J. Stirn (California Institute of Technology, Pasadena, CA (USA)). P. 606-25 of Proceedings of the ERDA Semiannual Photovoltaic Advanced Materials Programme Review Meeting (held Washington, DC, USA, 22 Mar. 1977). NTIS. In CONF-770318.

A programme to investigate the feasibility of growing large-grain polycrystalline GaAs by chemical-vapour deposition on recrystallized Ge films, to fabricate AMOS (antireflection-coated metal-oxide-semiconductor) solar cells on these films, and to further investigate the physics of AMOS cells on single crystals began in January 1976. Considerable improvements have been observed in the I-V characteristics of single-crystal AMOS solar cells, in which the oxide was grown by room-temperature exposure to water vapour-saturated O_2, although the best efficiencies have remained in the 15 to 16% range.

511/81 INVESTIGATION OF HETEROJUNCTION PHOTOCELLS WITH AN INTERMEDIATE ENERGY CONVERSION STAGE AT HIGH ILLUMINATION INTENSITIES. Z.I. Alferov, K.K. Aripov, B.V. Egorov, V.R. Larinov, V.D. Fedorova and L. Ernandes (A.F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad (USSR)). Soviet Physics - Semiconductors, vol. 14, no. 4, p. 403-6 (Apr. 1980) [English translation of Физики и Техника Полупроводников, vol. 14 (1980)].

The current-voltage characteristics and sensitivity spectra were determined for high-current AlGaAs heterojunction photocells with a built-in luminescence wavelength converter. A study was made of the influence of the degree of doping of the p-type converter layer on the sensitivity spectrum and on the internal resistance. Photocells with the optimal degree of doping $(N_A \simeq \times 10^{17}\ cm^{-3})$ illuminated with concentrated solar radiation had a power output up to 14.2 W (diameter 10 mm, degree of concentration K=1800, efficiency=15%). In the case of samples 4 mm in diameter a specific output power of 34 W/cm^2 and an efficiency of 18.2% (for K=2600) were achieved.

512/81 SILICON SOLAR CELLS BY HIGH-SPEED LOW-TEMPERATURE PROCESSING. A.R. Kirkpatrick, J.A. Minnucci and A.C. Greenwald (Simulation Physics, Inc., Bedford, MA (USA)). Institute of Electrical and Electronics Engineers Transactions on Electron Devices, ED-24, no. 4, p. 429-32 (Apr. 1977).

A new method for silicon solar-cell fabrication is being developed around ion-implantation and pulsed electron-beam techniques. Cells are fabricated totally in a vacuum environment at room temperature. Major reductions result in the time, energy consumption, and waste-material generation associated with solar-cell production. Cells to date have exhibited AM0 efficiencies exceeding 10%. 2 refs.

513/81 HIGH EFFICIENCY BIFACIAL BACK SURFACE FIELD SOLAR CELLS. A. Cuevas, A. Luque, J. Eguren and J. del Alamo (Instituto de Energía Solar, Escuela Técnica Superior de Ingenieros de Telecomunicación, Universidad Politécnica de Madrid, Ciudad Universitaria, Madrid 3 (Spain)). Solar Cells, vol. 3, p. 337-40 (1981).

The first high efficiency p^+-n-n^+ bifacial solar cells are presented. Efficiencies of 15.7% and 13.6% were measured under front and back AM1 illumination respectively at 28 °C. At 7 AM1 illumination and 28 °C the front efficiency increases to 16.5%. A pilot production of 200 cells was made following a fabrication process as simple as that for conventional back-surface field cells. Mean efficiencies of 13.4% and 10.7% were obtained under front and back illumination, respectively. The production yield is higher than 80%. 6 refs.

514/81 DEVELOPMENT OF HIGH EFFICIENCY (14%) SOLAR CELL ARRAY MODULE. SECOND QUARTERLY REPORT, MARCH 15-JULY 15, 1979. P.A. Iles, S. Khemthong, S. Olah, W.J. Sampson and K.S. Ling (Photoelectronics Division, Optical Coating Laboratory, Inc., City of Industry, CA (USA)). DOE-JPL-955217-2 (1979) 34p. NTIS. US$9.00.

Work on the development of large-area, high-efficiency p-n solar cells is described. The best performance achieved to date on 7.6 cm diameter cells is 15.6% at AM1 and 28 °C. Factors contributing towards the poor performance have not been identified and isolated. Work is continuing. Minor modifications have been incorporated in the modular design. The 120 cells will be connected 8 in parallel and 15 in series to enhance the reliability of the modules. As a result of the changes, two junction boxes which will be required as the p and n terminals will come out from the opposite sides of the module. Designs for a back-contact soldering machine, vacuum pick-up, AR-coating tooling, and test fixture have been completed. Fabrication of tooling has begun.

515/81 EFFECT OF ABRASIVE JET MACHINING (AJM) THE EDGE ON THE PERFORMANCE OF A POLYCRYSTALLINE SILICON SOLAR CELL. S.N. Singh, N.K. Arora and A. Prasad (National Physical Laboratory, New Delhi (India)). P. 286-91 of Proceedings of the National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Some p^+-n-n^+ poly-crystalline silicon solar cells of approximately 10% AM1 conversion efficiencies were subjected to a careful abrasive-jet machining (AJM) to remove a 0.5-mm broad rim from their periphery. On comparing the performance of each cell before and after AJM, it has been found that there is little or no reduction in its V_{OC} and virtually no change in its J_{OC} due to the AJM operation. However, its CF deteriorates substantially, thereby decreasing the conversion efficiency of the cell. A decrease in CF is mostly due to increases in the diode ideality factor, n, of the cell. An increase in n has its origin in the crystal structure of the single crystal grains near the periphery being damaged during the AJM operation and this damage being transmitted to a few tens of microns towards the centre of the solar cell.

516/81 SOLAR CELLS MOVE INTO NEW APPLICATIONS. International Power Generation, vol. 2, no. 7, p. 27-9 (Oct. 1979).

The photovoltaic installation at Schuchuli, a Papago Indian village in Arizona, is described and illustrated. The 24 1.2-m by 2.4-m panels supply power at 120 VDC for water pumping, lighting, refrigerators, a washing machine and a sewing machine, as well as battery charging. At Tangaye village in Upper Volta, a photovoltaic-cell array (1.8 kW peak) powers a grain mill and water pumping via a 120-V supply. At the Blytheville campus of the Mississippi College, USA, a 360-kW (peak) photovoltaic array of tracking concentrator cells includes liquid cooling of the cells which is used for domestic water heating. Overall efficiency is 14%. The use of photovoltaic arrays for powering microwave relays and cathode protection of pipelines is also briefly described.

517/81 PHOTOVOLTAIC POWER SYSTEM RELIABILITY CONSIDERATIONS. V.R. Lalli (Lewis Research Center, National Aeronautics and Space Administration, Cleveland, OH (USA)). P. 283-6 of Proceedings of the Reliability and Maintainability Symposium (held San Francisco, CA, USA, 22 Jan. 1980) No. 80CH1514-1R (1980).

An example is given of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems. This particular application was for a solar cell power-system demonstration project in Tangaye, Upper Volta, Africa. The techniques involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and failure mode and effects-analyses methods, and use of a fail-safe and planned spare-parts engineering philosophy. 3 refs.

518/81 NASA LEWIS RESEARCH CENTER PHOTOVOLTAIC APPLICATION EXPERIMENTS. A. Ratajczak, W. Bifano, J. Martz and P. O'Donnell. Paper 78-1768. American Institute of Aeronautics and Astronautics, NY, USA (1978) 8p.

In its role of supporting the US Department of Energy Photovoltaic Programme, the NASA-Lewis Research Center has designed and installed photovoltaic systems in 16 geographically different stations. Four additional experiments are now being carried out. These systems are powering refrigerators, highway warning lights, forest lookout towers, remote weather stations, water chillers and insect-survey traps. The experiments include applications of a power system to rural areas for the first time, an air-pollution monitoring system and a seismometer. The photovoltaic application experiments for water pumps and crop-grinding devices to be used by African villages are being prepared with the assistance of the US Agency for International Development. These systems are described in detail.

B3. Active Thermal Systems

519/81 EXPERIMENTAL INVESTIGATIONS OF A PHYSICAL SYSTEM CAPABLE OF USING SOLAR ENERGY. R. Rup (University of Delhi, Delhi (India)). Journal Physics, D, vol. 11, p. L207-9 (1978).

A physical system capable of using low-temperature differences is investigated. In an earlier publication, based on a simple theoretical model, the dynamics of a system with two working fluids (dry air (dry system) and air saturated with water vapour (wet system)) was described. This note reports a comparison between the experimental and theoretical results, both for the dry system and the wet system. The results are found to be in good agreement.

520/81 STUDIES OF A COMPACT SOLAR WATER HEATER. H.P. Garg and U. Rani (Centre of Energy Studies, Indian Institute of Technology, Hauz Khas, New Delhi 110016 (India)). Sunworld, vol. 5, no. 1, p. 17-8 (1981).

This article describes a solar water heater with a capacity of 90 liters and of compact construction. The results of the performance of the water heater are given including tests of the use of single versus double glazing and the effect of a night-time insulating cover. It is concluded that for domestic applications in India a single glass cover and a solar water heater with a 10-cm tank can be used to obtain temperatures up to 40 °C in the early morning following the application of a night-time insulating cover. 4 refs.

521/81 EXPERIMENTS ON FLOW-DOWN TYPE SOLAR HEAT COLLECTOR (流下式集熱器の実験). Tanaka S. and Kurihara J. (Tokai University, Tokyo (Japan)). P. 1-4 of Proceedings (Kōen Ronbunshū) of the Third Research Presentation Meeting (Dai-Sankai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nihon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 5-6 Dec. 1977). Japan Solar Energy Society, Bunkyō-ku, Tokyo, Japan (1977). In Japanese.

Specially designed flow-down type solar heat collectors equipped with evaporation-controlling covers on the channels were made for trial, to grasp and to improve the performance and to examine the possibility of cutting cost of the flow-down type solar heat collectors. The experimental values obtained agreed well with the theoretical values.

522/81 PERFORMANCE STUDY OF AIR-HEATED PACKED-BED SOLAR-ENERGY COLLECTORS. C.B. Mishra and S.P. Sharma (Department of Mechanical Engineering, Birla Institute of Technology, Mesra-835215, Ranchi (India)). Energy, vol. 6, p. 153-7 (1981).

A performance study of three packed-bed solar collectors for heating air is presented. Iron chips, aluminium chips, and pebbles have been used as packing materials. It is observed that the performance of plane collectors improves appreciably by packing with blackened metallic materials. Moreover, the packed-bed collector also works nicely as a thermal storage system. Iron-chip packed-bed collectors show the best performance. 6 refs.

523/81 MEASUREMENT OF FLAT-PLATE COLLECTOR HEAT LOSS COEFFICIENTS. N.M. Nahar (Central Arid Zone Research Institute, Jodhpur (India)). Regional Journal of Energy, Heat and Mass Transfer, vol. 3, p. 123-33 (1981).

Solar energy can be more efficiently trapped by optimized flat-plate collectors. An essential requirement for the design, development and installation of a solar water-heater system is to understand the performance characteristics of flat-plate solar collectors including the heat-loss characteristics. An indoor method has been developed and described in this paper for the direct measurement of U_L. The U_L is reported for bond duct-type collectors with single and double glazing each painted with black-board paint at zero wind speed and at controlled wind speeds. These results are in good agreement with the theoretical values. 12 refs.

524/81 CORRELATIONS AND TRANSITION REGIMES IN A THERMODYNAMIC SOLAR PUMP (CORRELATIONS ET

REGIMES TRANSITOIRES DANS UNE POMPE SOLAIRE THERMODYNAMIQUE). B. Fabre, R. Jacquier and D. Merle. Université de Dakar, Annales de la Faculté des Sciences, vol. 31, p. 49-57 (1980). In French.

This article describes the preliminary measurements made on the collectors, motor and pump of a solar-pump system. The sequence of temperature measurements made is described and the performance of the system is reported. 3 refs.

Cet article donne les premières mesures faites sur les capteurs, le moteur et la pompe. Il analyse la séquence des températures mesurées et le fonctionnement du système. 3 réf.

525/81 PERFORMANCE CHARACTERISTICS OF SOLAR REGENERATORS. P. Gandhidasan, V. Sriramulu and M.C. Gupta (Indian Institute of Technology, Madras (India)). P. 685-90 of Proceedings of the National Solar Energy Convention of Solar Energy Society of India (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

For regenerating absorbent chemical solutions, solar energy can be effectively used. This paper describes a method in which the absorbent solution flows over a solar collector as a thin film and the water evaporating from the liquid surface is removed by wind gusts or laminar air streams. In the forced-convection regenerator, the solution film and air stream can flow either concurrent or countercurrent to each other. A theoretical study has been made to predict the performance of these two types of regenerators and an experimental study has been conducted to study the performance of wind-forced and laminar-forced regenerators.

526/81 DESIGN AND PERFORMANCE OF AN AIR COLLECTOR FOR INDUSTRIAL CROP DEHYDRATION. P.W. Niles, E.J. Carnegie, J.G. Pohl and J.M. Cherne (California Polytechnic State University, San Luis Obispo, CA 93407 (USA)). Solar Energy, vol. 20, p. 19-23 (1978).

Test results are reported for the operation of unglazed and single-glazed solar collectors used to heat air to the 90 °C range. The collectors were constructed of standard black-painted metal decking and were tested in various lengths so that pressure drops and convective heat-transfer rates could be varied independent of collector operation temperature. It is shown that the experimental collector performance results with single-pass operation are in substantial agreement with standard collector-analysis procedures. These results give a firm basis for collector and system optimization. 7 refs.

On rapporte ici les résultats d'essais pour le fonctionnement de capteurs solaires sans vitrage ou à simple vitrage, utilisés pour le chauffage de l'air jusqu'à une plage de 90 °C env. Les capteurs furent constitués d'une plaque en métal peint en noir standard et testés en différentes longueurs pour que les chutes de pression et les taux de transfert de chaleur par convection puissent être variés, indépendamment de la température de fonctionnement des capteurs. On montre ainsi que les résultats de fonctionnement du capteur expérimental, dans le cas d'une opération à passage unique, sont en accord avec ceux des procédures d'analyse d'un capteur standard. Ces résultats donnent une solide base d'étude pour l'optimisation des capteurs et du système. 7 réf.

Se informa acerca de los resultados obtenidos en ensayos de funcionamiento de colectores solares con vidriado simple y sin él, usados para calentar aire a unos 90 °C. Los colectores fueron construídos con metal común de cubierta pintado de negro y se ensayaron en diversas longitudes,de manera que las caídas de presión y la transferencia convectiva del calor pudieran variarse independientemente de la temperatura de operación del colector. Queda demostrado que los resultados experimentales del comportamiento del colector, al funcionar en pasaje único, son básicamente acordes con el procedimiento de análisis de colectores comunes. Estos resultados dan una base firme para la mejor aplicación del colector y el sistema. 7 ref.

527/81 HEAT-COLLECTING CHARACTERISTICS OF REVERSE FLAT PLATE TYPE SOLAR HEAT COLLECTORS (逆平板型コレクタの集熱特性). Sakuta K., Sawada S., Tani T., Tanaka T. and Horigome T. (Electrotechnical Laboratory, Tanashi, Tokyo (Japan)). P. 93-6 of Proceedings (Kōen Ronbunshū) of the Fourth Research Presentation Meeting (Dai-Yonkai Kenkyū Happyōkai) of the Japan Solar Energy Society (Nihon Taiyō Enerugī Gakkai) (held Tokyo, Japan, 27-28 Nov., 1978). Japan Solar Energy Society, Bunkyō-ku, Tokyo, Japan (1978). In Japanese.

The results obtained from experiments performed to determine the heat-collecting characteristics of commercial-scale reverse flat-plate collectors are described. The collectors provide satisfactory heat-collecting efficiency at a temperature of the heat medium 100 °C higher than the ambient. Heat collection at this high temperature is made possible using a selective absorbing surface with a low heat-radiation rate, as convection heat loss is almost completely suppressed in these collectors.

528/81 ELLIPTICAL SOLAR REFLECTOR. R.V. Anderson. US Patent 4,164,934 (21 Aug. 1979). File date: 16 Aug. 1976. 6p.

A fixed low-cost solar energy-collecting device with an elliptical solar reflector is described which is capable of efficiently collecting and concentrating solar energy during all seasons and sun declinations while completely eliminating the need for a mechanism for shifting the reflector to follow the sun's path. The collector includes an elongated, trough-like reflector which substantially coincides with a section of a focal end surface of an imaginary elliptical cylinder, with a heat-exchange fluid tube positioned along the adjacent focal line of the imaginary elliptical cylinder. In this fashion, solar rays passing through or parallel to the remaining focal line of the imaginary cylinder and striking the reflector are focused onto the heat-exchange tube, so that solar energy collection is concentrated without the necessity of precisely orienting the reflector relative to the sun. A solar energy-collection device consisting of a plurality of juxtaposed reflector units is described in which the reflector focal lines are positioned along a geographic east-to-west line and at an angle of elevation equal to the latitude of the collector's position on the earth.

529/81 STUDIES INTO REDUCTION OF RADIATIVE HEAT LOSSES OF FLAT-PLATE SOLAR COLLECTORS. P. Brennecke and E. Justi (Technische Universität, Braunschweig (Fed. Rep. of Germany)). Revue Internationale de Heliotechnique, p. 18-24 (1976).

A report is given on investigations into the optimization of flat-plate solar collectors for production of warm water by minimizing the various heat losses, especially radiative ones. Such selective covers as commercial silicate glass, methacrylic acid methylester polymerisate glass ("Plexi-glass" or "Lucite") and organic ETFE (ethylene tetrafluorethylene polymerisate, "Hostaflon") foils, or combinations of them have been measured. The results of thermal measurements are discussed in terms of the carefully determined absorption spectra between 0.23 and 30-μm wavelength. Most attractive seems to be the transmission spectrum of acryl-glasses because it approaches best the ideal slope of the cutoff curve. However, this organic material is not useful in practice because it becomes soft at about 85 °C and because it loses its transparency by the formation of fine hair cracks after a few weeks of thermacycles. Nevertheless, Plexi-glass is commercially available in the form of flat sheets with integral-flow passages enabling thermostatic temperature control by circulation of fluids, especially pure water. In this way, the theoretical expectation could be verified that the radiative heat loss of such covers by infrared dipole radiation may be reduced appreciably by cooling them down to ambient temperature and that the maximum adiabatic temperature increase is improved by this method.

530/81 STATIC SOLAR TRACKER AND ENERGY CONVERTER. A.J. Hackworth. US Patent 4,167,936. File date: 8 Aug. 1977. 4p.

A fluid-containing tube is supported by a radially disposed, heat-absorbing fin so as to be coaxial with the reflective inner surface of a hemi-cylindrical reflector. Such a combination, if positioned with the reflector aperture substantially horizontal and with a north-south disposition of the reflector axis, or with the reflector aperture vertical (its axis substantially vertical and with a southern exposure of that aperture) will produce effective sun-tracking and efficient heating of the fluid in the tube throughout the daylight hours even though the reflector remains static.

B4. PASSIVE THERMAL SYSTEMS

531/81 THE THERMODYNAMIC CYCLE OF THE MINTO SOLAR WHEEL. Sui Lin. ASHRAE Transactions, vol. 86, no. 1, p. 408-19 (1980).

The concept of the Minto solar wheel is presented. Ideal and real thermodynamic cycles for this thermal motor are described. The ideal thermal efficiency of the Minto solar wheel is compared with that of an ideal Rankine-cycle system utilizing R-12 fluid without overheating at 21.1 °C. 2 refs.

532/81 SOLAR PONDS (NON-CONVECTIVE). H. Tabor (Hebrew University, Jerusalem (Israel)). P. 167-83 of Proceedings of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.)., Pergamon Press, New York, NY, USA (1979).

The physical properties of solar ponds are reviewed. The criterion for stability against mixing in a solution with both temperature and salinity gradients is given. The fraction of solar radiation that penetrates the horizontal surface of a solar pond is tabulated for various latitudes and seasons. Other factors contributing to the attenuation of insolation before it reaches the pond bottom are considered, including medium clarity and infrared absorption. Methods for maintaining a fixed salt concentration in the presence of diffusion and for extracting heat from a solar pond are discussed. Large convective zones are shown to be capable of attenuating the seasonal variations of the pond energy output. Some problems of solar ponds are considered. 15 refs.

533/81 FUNDAMENTAL STUDY ON SOLAR BRAZING. Sumitomo T. (Government Industrial Research Institute, Takamatsu, Kagawa (Japan)). P. 18-28 of Report (Kenkyū Hōkoku) of the Shikoku Industrial Technology Laboratory (Shikoku Kōgyō Gijutsu Shikenjō), vol. 11, no. 1 (1979). In Japanese.

A device has been developed with which

metals can be brazed by using concentrated solar energy. This paper describes the applicability of a parabolic mirror for a solar furnace and the results of the solar brazing of various metals. Experimental results were summarized as follows: (1) An aluminium parabola (330-cm aperture, 82.5-cm focal length, and 5 mm thick, its inner surface being wrapped by the reflective aluminized acrylic mirror) was used as the parabolic mirror. This was a light and low-cost mirror, but did not afford extremely high accuracy. (2) The maximum temperature measured at the focal point of the mirror was about 1500 °C in October. (3) Four kinds of metals were successfully brazed in air at temperatures of 700-1000 °C. 4 refs.

534/81 SIMPLE MULTIPLE WICK SOLAR STILL: ANALYSIS AND PERFORMANCE. M.S. Sodha, A. Kumar, G.N. Tiwari and R.C. Tyagi (Centre of Energy Studies, Indian Institute of Technology, New Delhi 110029 (India)). Solar Energy, vol. 26, p. 127-31 (1981).

This paper presents the design, analysis and performance of a multiple-wick solar still, in which blackened wet jute cloth forms the liquid surface which can be oriented to intercept maximum solar radiation and attain high temperatures on account of low thermal capacity. The wet surface consists of a series of jute cloth pieces of increasing length separated by thin black polythene sheets, resting on foam insulation supported by a net of nylon ribbon; these pieces are arranged along an incline and their upper edges are dipped in a saline-water tank. Suction by the capillary action of the cloth fibre provides a thin sheet of liquid on the cloth; the arrangement ensures that all the surface irradiated by the sun is wet at all times. The results of an analysis based on Dunkle's relation are in excellent agreement with the observed performance of the still. On a typical cold sunny day in Delhi the distillate output was 2.5 l/m^2-day, corresponding to an overall efficiency of 34% (as compared to a maximum of 30% for basin-type stills). The still costs less than half of the cost of a basin-type still of the same area and provides a higher yield of distillate. 19 refs.

535/81 EXPERIMENTAL STUDY OF THE INFLUENCE OF HEAT TRANSPORT MEDIUM TEMPERATURE AND VELOCITY ON DRYING INTENSITY IN CHAMBER-TYPE SOLAR DRYERS. A. Akhmadaliev (Fergana Polytechnic Institute, Fergana, Uzbekh SSR (USSR)). Applied Solar Energy, vol. 16, no. 4, p. 79-80 (1980) [English translations of Гелиотехника, vol. 16, no. 4, p. 78-9].

Results are presented of studies of fruit-drying duration as a function of drying-agent temperature and velocity. Simple empirical expressions are obtained which show the dependence of drying on the drying-agent temperature and velocity and the dependence of the drying-process duration on the drying coefficient. 3 refs.

536/81 A SOLAR BRICK-DRYING EXPERIMENT. M.A. Abdelrahman (University of Petroleum and Minerals, Dharan (Saudi Arabia)). Sunworld, vol. 5, no. 1, p. 8-9 (1981).

The availability of large quantities of river-bank clay for brick making, the resistance of red bricks to environmental deterioration and favourable thermal-insulation properties make red bricks a desirable building material in Sudan. This article describes an improved brick-drying process using solar-heated air. Sample bricks dried in a solar dryer were found to produce crackless bricks as opposed to the traditional direct-exposure method. Furthermore, drying time was reduced by about 40%. 4 refs.

537/81 PASSIVE SOLAR PROGRESS. J.I. Yellott. Heating, Piping and Air Conditioning, vol. 52, no. 1, p. 57-66 (Jan. 1980).

The paper presents a review of the literature and discusses the developments in passive solar-heating and -cooling systems that are in use in residential and commercial buildings. 9 refs.

538/81 PASSIVE DESIGNS FOR DESERT HOUSES. J. Cook. Solar Age, vol. 6, no. 2, p. 26-33 (1981).

This article describes techniques for climatizing homes in low, hot deserts with extreme temperatures similar to those found in Southwest, USA. Details are included of various techniques for insulating foundations, insulating walls (including those made of wood and masonry) and for ventilating and insulating roofs.

C. BIOCONVERSION ENERGY

539/81 BIOCONVERSION: ENERGY AND AGRICULTURE (BIOCONVERSION: ENERGIE ET AGRICULTURE). P.A. Jayet (Institut National de la Recherche, Agronomique (France)). Revue de l'Energie, vol. 30, no. 313, p. 267-78 (Mar. 1979). In French.

Bioconversion permits the fabrication and storage of vegetable matter or of "biomass": it is a biochemical means of collecting and storing solar energy, comparable to the action performed by "physical collectors" (plane collectors, concentration-type power stations, and solar batteries). The energetic exploitation of secondary projects from agriculture and forestry (and, in a longer-range view, perhaps the cultivation of energy-producing crops) provide bioconversion with a significant place among the new energy resources.

La bioconversion permet la fabrication et le stockage de matière végétale ou de "biomasse": c'est une filière biochimique de collecte et de stockage de l'énergie solaire comparable à l'action de "capteurs physiques" (capteurs plans, centrales hélio-electriques à concentration, piles solaires). L'exploitation énergétique des sous-produits de l'agriculture et de la sylviculture (et, à plus long terme éventuellement les cultures énergétiques) confèrent à la conversion microbiologique une place de choix parmi les énergies renouvelables.

540/81 AUTOMOTIVE FUELS FROM CELLULOSE MATERIALS. B. Higginson and R.H. Thornton (New Zealand Energy Research and Development Committee, Auckland (New Zealand)). NZERDC-49 (1980). New Zealand Energy Research and Development Committee, Auckland, New Zealand. 28p.

The results of this investigation show that it is feasible to link the alcohol-fermentation and anaerobic digestion processes to a system for the production of both alcohol and methane from organic substrates. The rate of ethanol production has been determined with respect to cell concentration and the prerequisite of both a high cell concentration and yeast recycling has been shown. Ethanol fermentation under reduced pressure has been shown to be feasible and to give higher ethanol productivities. Although optimization of fermentation has been attempted in this report, with due regard to energy conservation, for industrial application the cost of sugar will be the overriding factor. Cysewski and Wilke pointed out that the cost of sugar overwhelms all other costs in the production of ethanol by fermentation: up to 70 to 80% of the total cost of the ethanol. Results showed that the resultant fermentation spent wash and extracted crop residues could be anaerobically digested to produce methane (and carbon dioxide). A hydraulic retention time of 10 days or longer was needed for effective digestion in which a reduction of chemical oxygen demand (COD) of up to 85% was achieved. Results indicated that further reduction in retention time may be possible if the microbial biomass could be either retained on support media, or recycled more effectively. A gas production rate of 4270 liters of gas/m^2 of culture/day at 11.6-day retention time was obtained with the anaerobic contact digester using fodder beet spent wash. Using the same substrate, results over short periods with the anaerobic-filter system could produce up to 4.8 liters of gas/liter of culture/day. The high methane composition of this gas (75 to 80%) makes this an attractive proposition.

541/81 PARTICULAR PROBLEMS OF SOLID WASTE RECLAMATION IN DEVELOPING COUNTRIES. C. Rolz. Journal of Applied Chemical Biotechnology, vol. 28, p. 321-39 (1978).

Types of agricultural wastes generated by tropical countries are considered and examples of reclamation projects are given, e.g., recovery of cellulose, methane production, pyrolysis, processing of coffee wastes and production of ethanol.

C1. Biomass Production and Conversion

542/81 CONVERSION FACTORS FUELWOOD:OIL. M. Nylinder (Sveriges Lantbruksuniversitet, Uppsala Institutionen foer Virkeslaera, Uppsala (Sweden)). SIU-IVI-110 (1979) 56p. NTIS. US$10.50.

The effective-heating value of wood or bark fuels is strongly dependent on the moisture content. The heating value per kg of dry wood is about the same for all tree species and tree parts. The effective heating value is about 18 to 13 MJ per kg of dry wood at a moisture content (green basis) of 30 to 50%. Because of great variations in basic density for different tree species, the effective-heat value varies quite a lot when it is expressed per unit volume. The effective-heat value varies from 6 to 9 GJ per m^3 solid wood at a moisture content (green basis) of 50 to 30%. The amount of wood with a moisture content of 40 to 50% which generate the same heating value as one m^3 of oil (3 to 5) with regard to efficiency is as follows: pine-stemwood: 5.8 to 6.5 m^3 solid per m^3 oil; pine-residuals: 6.0 to 6.4 m^3 solid per m^3 oil; spruce-stemwood: 6.0 to 6.5 m^3 solid per m^3 oil; spruce-residuals: 5.1 to 6.1 m^3 solid per m^3 oil; birch-stemwood: 4.8 to 5.2 m^3 solid per m^3 oil; birch-residuals: 4.8 to 5.2 m^3 solid per m^3 oil. The conversion factors by weight will for all species be: 2.4 to 2.6 tonne (dry matter) per m^3 oil: 4.1 to 5.3 tonne (green matter) per m^3 oil.

543/81 ALCOHOLS AS FUELS - THE GLOBAL PICTURE. R.F. Ward (United Nations, DC 810, New York, NY 10017 (USA)). Solar Energy, vol. 26, p. 169-73 (1981).

A number of countries have programmes which encourage the production and use of ethanol and methanol to extend gasoline supplies. These programmes are often based on food crops which are subject to wide variations in both cost and availability. Some of the programmes are reviewed, and the costs of alcohols are compared to world market prices of gasoline. 25 refs.

544/81 STATUS OF ETHANOL FUEL SUPPLY FROM ENERGY FARMING (エタノール燃料の供給問題). Shozawa H. Journal of the Fuel Society of Japan (Nenryō Kyōkai Shi), vol. 59, p. 191-201 (1980). In Japanese.

Plans for the production of ethanol in several countries are presented. The cost and energy balance of ethanol production from various plants are considered. It is recommended that sweet potatoes be used as a source of ethanol feedstock in Asia.

545/81 METHOD AND APPARATUS FOR UTILIZING ALCOHOL AS FUEL FOR INTERNAL COMBUSTION ENGINE. J.M.R. Concepcion. NSDB Technology Journal, vol. V, no. 2, p. 56-9 (1980).

A method of utilizing alcohol fuel as fuel for gasoline-powered internal combustion engines comprises the steps of: maintaining alcohol and gasoline in separate fuel tank; withdrawing the alcohol and gasoline fuel respectively on separate fuel lines; filtering alcohol fuel on a filtering unit connected on the alcohol fuel line; passing and regulating separately the alcohol and gasoline in a double-acting metering device communicably connected on the fuel lines; simultaneously conveying separately the gasoline and alcohol fuel emanating from the metering device in separate outlet lines; conveying the alcohol fuel in the outlet lines into a vaporizer unit and the gasoline fuel in a filtering unit prior to its introduction to the carburetor of the engine; heating the alcohol in the vaporizer unit into vaporized form by simultaneous introduction of hot air emanating from the engine positive crankcase ventilation through an air line coiled in the exhaust pipe which acts as a heat exchanger; and simultaneously conveying and blending the alcohol vapour obtained from the vaporizer unit and the gasoline fuel into the intake manifold and carburetor of the engine.

546/81 STUDIES ON THE PRODUCTION OF ALCOHOL FROM CANE-MOLASSES. V.C. Nair and H.V.R. Iyengar (E.I.D.-Passy India, Ltd., Madras 600001 (India)). Chemical Age India, vol. 29, p. 948-50 (1978).

This article describes an improvement in the efficiency of fermenting molasses into alcohol obtained by cooling to 32-33 °C in an industrial installation.

547/81 SUGAR CANE INDUSTRY IN THE ENERGY CRISIS (LA INDUSTRIA DE LA CAÑA DE AZUCAR EN EL MARCO DE LA CRISIS ENERGETICA). G. Llerena, P. López Guzmán and C. de Armas Casanova (Instituto Cubano de Investigación de los Derivados de la Caña de Azúcar, La Habana (Cuba)). P. 229-39 of Caribbean Consultation on Energy and Agriculture (Consulta del Caribe Sobre Energía y Agricultura). Instituto Superior de Agricultura, Santiago, Chile (1980). In Spanish.

The increase in the price of petroleum in 1973 made the world conscious of the problems due to the scarcity of fuel. Sugar-cane could be used as a means to transform solar energy into fuel and raw material for the chemical industry. Besides using sugar-cane for cattle and human nutrition as in the past, the alcohol produced from sugar-cane and combined with gasoline has been exploited for industrial and domestic purposes. The bagasse from sugar-cane can be used as a resource for the production of electric power. Plants to recover the energy lost in this process could be built. The by-products derived from the sugar-cane industry have applications for human and animal nutrition, for land protection, for the chemical industry and for the production of other products. Sugar-cane used as an energy resource has the advantage of being a renewable resource, which presents a lot of possibilities for the industrial development of the tropical countries. 4 refs.

El aumento en los precios del petróleo en 1973, nos hizo conscientes del problema surgido por la escasez del combustible. La caña de azúcar puede ser un excelente medio para transformar la energía solar en combustibles y fuente de materia prima para la industria química. Además de usarse la caña de azúcar en la nutrición humana y animal, en los últimos años, el alcohol producido de la caña, combinado con la gasolina, ha sido explotado con propósitos industriales y domésticos. El bagazo de la caña puede también ser fuente de producción de energía eléctrica. La industria azucarera debe trazar planes de ahorro de energía. Se podrían diseñar plantas que recuperen la energía perdida en el proceso; de esta forma se podría usar esta energía nuevamente. Los subproductos derivados de la industria azucarera tienen diferentes aplicaciones: como alimentación animal, para la protección de terrenos, las industrias químicas y para la producción de otros productos. La caña de azúcar, utilizada como fuente de energía, tiene la ventaja de ser un recurso renovable, que presenta muchas posibilidades para el desarrollo industrial de los países tropicales. 4 refs.

548/81 PRODUCTION OF SUGARCANE AND TROPICAL GRASSES AS A RENEWABLE ENERGY SOURCE. THIRD QUARTERLY REPORT, DECEMBER 1, 1978-FEBRUARY 28, 1979. A.G. Alexander, W. Allison and M. Garcia (Agricultural Experiment Station, Puerto Rico University, Rio Piedras, Puerto Rico (USA)). ORO-5912-T1 (1979) 45p. NTIS. US$8.50.

Research continued on candidate screening, water and nitrogen regimes, and ratoon-crop performance for row-spacing, harvest-frequency, and varietal variables. Greenhouse tests revealed several grasses having growth and drought-tolerance characteristics superior to Sordan 70A, the project's outstanding short-rotation candidate up to this time. Johnson grass (Sorghum halepense), regarded as a weed by local farmers, gave very favourable growth performances under simulated arid and semi-arid conditions. At six months into year 2, first ratoon data for sugar-cane and Napier grass indicate yield increases of 33 and 4%, respectively, over plant crop yields. NCo 310 is emerging as the outstanding sugar-cane variety tested to date. There are no consistent responses to narrow row spacing. Frequent recutting (at 2-month intervals) is gradually destroying sugar-cane but is not appreciably affecting Napier grass. Preliminary field-scale operations were begun with performance tests on a Mathews Company rotary scythe.

549/81 COMPACTION AND DENSIFICATION OF FUELS FROM BIOMASS. E.E. Robertson (Biomass Energy Institute, Inc., Winnipeg, Manitoba (Canada)). P. 1091-103 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

The possibility of upgrading techniques for recovering energy from biomass sources is considered. The history of densifying biomass is briefly reviewed, and the role of binders for densified biomass is discussed. Design criteria and equipment selection for a pelleting plant are specified. Several organizations which are involved in pelletizing biomass for fuel are mentioned. 11 refs.

550/81 ECONOMIC FEASIBILITY OF GASIFICATION IN NIGERIA. P.B. Onaji, S.S. Adefia and A.A.C.M. Beenackers (Department of Chemical Engineering, Ahmadu Bello University, Zaria (Nigeria)). Chemical Age of India, vol. 31, no. 3, p. 194-7 (1980).

The economic feasibility of gasifying agricultural and forestry wastes in Nigeria was studied. The cost of the electricity produced by a diesel engine fueled with diesel oil or gas is compared with that produced from an electric supply grid. 9 refs.

C2. Biogas Production and Utilization

551/81 THE CONSTRUCTION OF SIMPLE BIOGAS DIGESTERS IN THE PROVINCE OF SZECHWAN, CHINA. Su-Te Shian (South West Buildings Design Institute, State Capital Construction Commission, Chengde, Sichuan (China)). Agricultural Wastes, vol. 1, p. 247-58 (Nov. 1979).

Around 5 million household-size digesters are in service in the province of Sichuan alone, mostly of a low-cost circular shallow design. Construction materials include concrete or a lime-clay mixture, with a fixed roof covered with soil to maintain digester temperature. Sizes vary from 5 to 100 m^3, yielding approximately 0.15 m^3 of gas daily with a calorific value of 5500 kcal/m^3. Digesters are normally emptied twice a year, and are restarted with rice straw. The fixed roof causes the gas produced to force the liquid level in the digester downwards (if not drawn off), and into the inlet and outlet pits, which helps to retard scum formation.

552/81 BIOGAS IN CHINA: SMALL SCALE-DECENTRALIZED ANAEROBIC DIGESTION. H. Kaufman. Alternative Sources of Energy, no. 51, p. 24-7 (1981).

This article describes the biogas systems in use in the Xinbu brigade in Guangzhou, China. While emphasis is placed on the construction, operation, maintenance, benefits, problems, improvements, developments and wider applicability of biogas in this community, biogas is only one element of the entire rural energy production system of the Xinbu brigade.

553/81 SMALL-SCALE BIOGAS PROCESSING FACILITIES. M.R. Brule and S.S. Sofer (Kerr-McGee Corporation, Oklahoma City, OK (USA)). P. B1-20 of Proceedings of the Gas Conditioning Conference (held Norman, OK, USA, 6 March 1978). University of Oklahoma, Norman, OK, USA.

Energy shortages and pollution problems have continued to accelerate interest in biogas plants for industry and agriculture. Recently several commercial large-scale anaerobic-digestion facilities have come on stream in the wake of dwindling natural-gas supplies. Small-scale units are also being implemented to supplement energy requirements for dairies and farms. The current status of these methane-from-cow-manure plants is reviewed herein. The intent of this paper is to acquaint those interested in, but not intimately familiar with, this field with current work in bio-gasification systems. Particular emphasis is on small-scale units; design criteria and economic considerations are discussed for an actual working unit. Further insight is offered through a comprehensive survey of the literature.

554/81 A COMMERCIAL APPROACH TO BIOGAS EXTENSION IN NEPAL. D.J. Fulford (Development and Consulting Services, United Mission to Nepal, Butwal (Nepal)). Appropriate Technology, vol. 8, no. 2, p. 14-6 (1981).

This article describes an attempt to solve the problems encountered in adopting a commercial approach to the manufacture and extension of intermediate technologies in Nepal. The specific problems include both research and development and management difficulties. The experience suggests that a commercial approach to the extension of biogas does work and is more effective than other approaches despite certain problems. It is pointed out that care must be taken to research the social organization that may be required to use such an intermediate technology most effectively, such as through a co-operative or community approach. 4 refs.

555/81 METHANE PRODUCTION BY MICROORGANISMS (微生物によるメタン生産). Tanaka K. Journal of the Fuel Society of Japan (Nenryō Kyōkai Shi), vol. 59, p. 159-63 (1980). In Japanese.

This paper examines the separation of the bacteria involved in anaerobic fermentation into methanogenic bacteria and non-methanogenic bacteria which produce substrates for methanogenic bacteria. Examples are given of the symbiotic relationship between these two types of bacteria. The methanogenic fermentation of urban wastes in Japan is reviewed. Research programmes to be carried out are included. 43 refs.

556/81 FERMENTATION PARAMETERS NEEDED TO IMPROVE BIOGAS PRODUCTION. G. Anglo (National Institute of Science and Technology, Manila (Philippines)) and R.V. Alicbusan. NSDB Technology Journal, vol. V, no. 2, p. 34-41 (1980).

Swine waste has been reported to be a good source of organic substances for microbial growth and activities. Biogas, composed mainly of methane and carbon dioxide, is one of the products of its fermentation under anaerobic conditions. Gas production is enhanced with the use of methane starters. Under optimum conditions of inoculum size, pre-treatment, dilution, pH, agitation, light intensity and addition of actizyme, maximum gas production can be obtained after 30 days of anaerobic fermentation. 8 refs.

557/81 ANAEROBIC FERMENTATION OF ANIMAL MANURE. A.G. Hashimoto, Y.R. Chen, V.H. Varel and R.L. Prior (USDA, Clay Center, NE (USA)). American Society of Agricultural Engineers Technical Paper 57 (1979). Proceedings of the ASAE and CSAE Canadian Society of Agricultural Engineering Summer Meeting (held Winnipeg, Canada, 24 June 1979). American Society of Agricultural Engineers, St. Joseph, MI, USA.

This paper discusses the major factors involved in the anaerobic fermentation of animal manures, including: the microbiology of methanogenesis; fermentation kinetics; biogas handling and use; and an economic assessment for beef feedlots. The anaerobic fermentation process is technically feasible, and is economically feasible in certain instances. 97 refs.

D. WIND ENERGY

558/81 CHARACTERISTICS AND USES OF WIND MACHINES. M.F. Merriam (University of California, Berkeley, CA (USA)). P. 665-718 of Part A of Solar Energy Technology Handbook. W.C. Dickinson and P.N. Cheremisinoff (eds.), Marcel Dekker, Inc., New York, NY, USA (1980).

Information is presented concerning: characteristics of wind machines; types of horizontal-axis machines; types of vertical-axis machines; uses of wind machines; and environmental aspects. 59 refs.

559/81 WINDENERGIE IN THEORIE UND PRAXIS. GRUNDLAGEN UND EINSATZ (WIND ENERGY IN THEORY AND PRACTICE. BASIC AND APPLICATIONS). J.P. Molly (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt eV, Stuttgart (Fed. Rep. of Germany)). Institut für Bauweisen- und Konstruktionsforschung, Karlsruhe, Fed. Rep. of Germany (1978). 138p. In German.

The first chapter of the book deals with the theory of wind turbines. After an outline of the distribution of wind currents on the earth and characteristic features of these currents, the third chapter then discusses the design of wind energy converters. The 4th and 5th chapters give a survey of projects realized and of the results of research programmes in this field. Finally, the author deals with the problem of investment and operating costs of wind-power plants.

560/81 WINDPOWER PROGRAMMES IN TANZANIA. R.S. Reichel (Electrical Engineering Department, University of Dar-es-Salaam, Dar-es-Salaam (Tanzania)). Vol. 2, no. 1, A5.45-5.52 of Proceedings of the Second International Symposium on Wind Energy Systems (held UK). 1978.

In Tanzania, windmills have been used for years, but only on a small-scale. The windmills presently used for pumping were all imported. This report gives an assessment study of the electricity demand in the rural areas of Tanzania. Since the use of a large-scale electricity transmission network is not justified due to the extremely small electric-power load, conventional methods can hardly be applied. The generating costs of windmills in the rural area are economical compared to the costs of electricity for commercial use in Tanzania. The report indicates that the majority of the various development plans in the field of wind energy focus on the manufacture of a low-cost windmill. 7 refs.

561/81 THE NEW ALCHEMY SAILWING. E. Bernhart and G. Hirshberg. The Journal of the New Alchemists, no. 5, p. 31-6 (1979).

The design (1977-78) is a culmination of four years of research and experimentation, originating from the construction of a water-pumping windmill by M. Sherman in India during 1973-74. The evaluation of the design through the years and the modifications made are described. The windmills are of the horizontal-axis, downwind, and sail-wing type. The rotor assembly is mounted on a steel turntable so that the rotor is always perpendicular to the wind direction. The sail assembly contains three dacron sails with an arrangement for automatic feathering and furling. Power is transferred along the rotating axle through a pair of commercial bearings. Five distinct stroke settings are provided by holes drilled at different radiations on the adjustable crank disc. From the disc, the power is carried down a wooden lattice tower (8 m) along a 7.6-cm diameter shaft to a diaphragm tire pump at ground level. The windmill discharges 3.3 liter/50-mm stroke at a 13- to 15-km windspeed. In 1979, modifications were made for revising some components requiring machine-shop skills and equipment for construction. The redesigned unit was fabricated with moderate skills and readily available welding equipment. One unit has been reported to be working flawlessly in an aquaculture project, pumping close to 3400 liters per hour in a wind of 16 km/h.

562/81 PERFORMANCE CHARACTERISTICS OF SAIL-TYPE HORIZONTAL AXIS WIND ROTORS. S.P. Govinda Raju and P. Sundaram (Indian Institute of Science, Bangalore (India)). P. 437-42 of Proceedings of National Solar Energy Convention (held Bombay, India, 13-15 Dec. 1979). Indian Institute of Technology, Bombay, India (1979).

Horizontal-axis sail-type wind rotors are simple to construct and have a good starting torque and efficiency. Thus, they appear to be very suitable for wind pumps for use in rural areas. However, detailed performance data on such rotors, necessary for optimal design, is not available. To fill this gap, tests were conducted on rotors of about 1.25-m diameter employing six sails of both triangular and nearly rectangular shape. Attention was given to the rigging of the sails to obtain optimal performance. Based on these tests, it is concluded that sail-type rotors with triangular sails can give a power coefficient of about 0.3. Rotors with rectangular sails give a power coefficient of over 0.33. In addition, they have a starting torque about twice that of rotors with triangular sails and, hence, appear to be well suited for applications demanding high starting torque.

63/81 AERODYNAMIC STUDIES OF A STRAIGHT-BLADED VERTICAL AXIS WIND TURBINE. W.S. Bannister (Department of Mechanical Engineering, Napier College of Commerce and Technology, Edinburgh (UK)). P. 88-101 of Proceedings of the First British Wind Energy Association Wind Energy Workshop (held UK, April 1979).

A straight-bladed vertical-axis wind turbine, 3 m in diameter and with blades 2 m in length, has been constructed as a test bed to evaluate various blade configurations. The design incorporates a number of horizontal cross arms connected to the blades, and a theoretical analysis has been performed to assess the drag of the cross arms, the effect of operation at low Reynolds numbers and the effect of induced drag. The turbine is shown to be robust and capable of operating with high efficiency at high wind speeds. 7 refs.

64/81 THE APPLICATION OF WIND ENERGY SYSTEMS TO DESALINATION. E.A. Adwallader, J.E. Westberg and W.R. Williamson. PB Report 276174 (1977) 68p. NTIS. US$10.50.

Seawater desalination has become increasingly difficult economically as a result of the sudden increase in fuel prices. However, a solution to this problem can be found using wind energy in conjunction with ion exchange with resinous membranes. Electric-power costs of US$0.05-0.018/kWh can be expected using presently available windmills and those under development. It is expected that this cost will decrease to less than US$0.26/kl using large-scale wind-energy desalination systems. This paper describes the characteristics of the wind, windmill capabilities, the development and evaluation of horizontal- and vertical-axis windmills, and the desalination system.

E. ENERGY STORAGE

565/81 ENERGY STORAGE. J. Jensen. Butterworth, (London (UK)). 101p.

This book describes the various technologies of energy storage including latent- and sensible-heat storage, chemical storage, mechanical storage and electrical storage. Examples are given of processes now in use with estimates of their costs.

566/81 COMPARISON BETWEEN THE PERFORMANCE OF THREE DIFFERENT METHODS FOR STORAGE OF LOW TEMPERATURE HEAT (SOLARHEAT) FOR SPACE HEATING. Styrelsen Foer Teknisk Utveckling (Stockholm (Sweden)). STU-1-156-1979 (1979) 62p. In Swedish.

The following systems were studied: a solar pond with a hot-water heating system, and air-heating systems with heat storage in a rock bed or as latent heat in salt hydrates. In the cost estimates, a typical system with 30-m^2 solar collectors and a storage need of 100 kWh was used. The air systems were found to be cheaper than the water, and latent-heat storage cheaper than rock-bed storage.

567/81 CENTRAL STORAGE FOR SOLAR ACTIVE SPACE HEATING. H.G. Lorsch and K.W. Kauffman (Franklin Research Center, Philadelphia, PA (USA)). P. 85-95 of Proceedings of the Solar Energy Storage Options Workshop (held San Antonio, TX, USA, 18 March 1979). NTIS. US$27.00 for complete proceedings (CONF-790328).

The status of various storage technologies for solar space-heating systems is reviewed. Sensible-heat storage in water and rock beds, latent-heat storage in phase-change materials, and thermochemical heat storage and chemical heat pumps are considered. Standards for measuring the performance of thermal-storage devices are reviewed.

568/81 INVESTIGATION OF HEAT STORAGES WITH SALT HYDRATE AS STORAGE MEDIUM BASED ON THE EXTRA WATER PRINCIPLE. S. Furbo (Thermal Insulation Laboratory, Danmarks Tekniske Hoejskole, Lyngby (Denmark)). Danmarks Tekniske Hoejskole, Lyngby, Denmark (1980) 83p.

Experimental and computational studies of a full-scale heat storage with salt hydrate as the storage medium and based on the extra-water principle are reported. Two different types of full-scale heat storage, both making use of an incongruently melting salt hydrate as a storage medium and based on the extra water principle, were examined by means of long-term experiments. In the first heat-storage type, oil as the heat-transfer fluid in direct contact with the storage medium was used. The second storage type was a mantle storage where water as a heat-transfer fluid was circulated in the mantle. No decrease in the performance of the storage during the long-term experiments was observed, and experiences for both storage types are obtained. By means of computer calculations, heat-of-fusion storage with oil as the heat-transfer fluid in direct contact with the storage medium were compared with hot-water storage as part of solar-heating systems with the Danish Reference Year as a basis. With results of these calculations, examples of economical comparisons between heat-of-fusion storage and hot-water storage are carried out. Considerations and experiments concerning storage material, stability of heat storage, and heat-transfer capacity are carried out.

569/81 IMPROVEMENT IN THE HEAT EXCHANGE PERFORMANCE (AMELIORATION DES PERFORMANCES DE TRANSFERT D'UN STOCKAGE DE CHALEUR PAR CHANGEMENT DE PHASE SOLIDE-LIQUIDE). A. Bricard, M. Berthoux and B. Duret (Direction Générale de Recherche Scientifique et Technique, Paris and Centre d'Etudes Nucléaires de Grenoble, Grenoble (France)). DGRST-77-7-1236 (1979) 46p. In French.

Equations relating the hydrodynamics and heat transfer involved in the charging and discharging of a direct-contact heat-storage system using paradichlorobenzene and water are developed and verified experimentally. The results indicate that a storage system of this type performs 10 times more effectively than the reservoir-type system. 16 refs.

Etude et vérification expérimentale des équations de nature hydrodynamique et thermodynamique ayant trait à un système de stockage de chaleur par contact direct utilisant le paradichlorobenzène et l'eau. Les résultats montrent qu'un tel système de stockage est dix fois plus efficace que les systèmes à réservoir. 16 réf.

570/81 EXPERIMENTAL INVESTIGATION OF THE THERMAL PERFORMANCE OF A TWO-COMPARTMENT WATER STORAGE TANK. S. Lin (Concordia University, Montreal (Canada)). Vol. 1, sections 14-25, p. 17.1-17.5 of Proceedings of the 1977 Annual Meeting of the American Section of the International Solar Energy Society (held Orlando, FL, USA, 6 June 1977). C. Beach and E. Fordyce (eds.), American Section of the International Solar Energy Society, Cape Canaveral, FL, USA (1977).

A water-storage tank consisting of two compartments stacked vertically was experimentally investigated. The assembly operates as a temperature filter. Only when the water in the lower tank becomes hotter than that in the upper tank, can it enter the upper one. The main characteristic of the two-compartment water-storage tank is that water in the upper tank is maintained at a nearly uniform temperature and always hotter than that in the lower tank.

F. SOCIO-ECONOMIC ASPECTS

571/81 RURAL ENERGY AND DEVELOPMENT: A STRATEGIC PLANNING ANALYSIS. R.S. Ganapathy (Indian Institute of Management, Ahmedabad 380015 (India)). P. 20-36 of Southern Perspectives on the Rural Energy Crisis. Nautilus, Inc., Box 353, Bolinas, CA 94924, USA (August 1981).

This paper analyses rural energy problems in the broad development contacts and present approaches to rural energy planning and policy options to deal with the rural energy crisis with particular reference to renewable energy sources. The general policy options proposed include: (a) the need to make rural energy strategy, particularly on an integrated rural development strategy; (b) a reduction in the importance of market efficiency as a criteria for rural energy development; (c) careful design for the development, transfer and use of rural energy technology from the specific interest of the rural poor; (d) the need for assistance to rural communities in building a secure energy future but of a catalytic and facilitative nature; (e) the encouragement of decentralized planning with co-ordination at the national level; (f) promotion of village utility on a co-operative or democratic basis; (g) the facilitation of community participation with restriction of commercial penetration in the rural energy field; (h) education and training for the development of endogenous strategies for rural energy; (i) the dependence of rural energy performance on local resources, skills, leadership and contextual factors; (j) the elimination of the complex system of subsidies, tax incentives and public expenditure in favour of urban, non-renewable energy use; (k) information systems and exchange that are carefully designed towards the real needs and capacities of the rural communities; (l) the selection of world energy systems that do not require non-renewable material for manufacture, transportation, installation, operation and repair;

(m) special emphasis on the particular problems of small countries; (n) the need for respective institutional capability to analyse and plan energy on the basis of democratic control; and (o) structural change at the national level or at least the development and implementation of transitional strategies which permit a gradual structural change. The article concludes with five policy options available to the international community which could help them contribute towards a solution of the rural energy crisis. 56 refs.

572/81 ECONOMICS OF PRODUCTION OF BIOGAS FROM SPECIFICALLY-GROWN PLANT MATERIAL. D.J. Stewart (Ministry of Agriculture and Fisheries, Mosgiel (New Zealand)). Paper 8 of Proceedings of the Third New Zealand Energy Conference (held Wellington, New Zealand, 12 May 1977) 13p.

The production of biogas from plant materials is technologically very simple, and is the only process currently available (other than direct burning) for the conversion of cellulosic materials into energy or fuels that is feasible at a farm scale, or even a home scale, as well as a large industrial-plant scale. For this reason the economics of biogas production can be considered at the farm scale as well as the industrial scale. An accurate assessment of the economics at the farm scale is possible, because commercially produced units are now available in New Zealand and in operation. However, although large-scale plants have been proposed and costed in the USA for the conversion of the cellulose component of garbage into biogas, operational data are not yet available, and the costing has not been applied to the use of specifically-grown plant material. Nevertheless, the large-scale plants envisaged use a large number of digesters each of 378,500-liter capacity and can thus be regarded as a combination of farm-size units, although with some economics in digester size, number of pumps required, etc. For these reasons, this review of the economics of biogas production is based on the operation of commercial 75,700-liter digesters available in New Zealand for farm-scale use. Factors governing the economics of farm-scale and industrial-scale production of biogas are also discussed.

573/81 ECONOMICS OF SELECTED WECS DISPERSED APPLICATIONS. S. Krawiec (Solar Energy Research Institute, Golden, CO (USA)). SERI/TR-431-580 (Apr. 1980) 41p. NTIS. US$8.50.

An economic analysis for distributed wind-energy conversion systems has been conducted for the US Department of Energy as part of the Solar Commercial Readiness Assessment task at the Solar Energy Research Institute. The objective of this paper is to analyse: the cost of electricity generated by selected wind-energy systems in residential and agricultural applications; the breakeven cost of wind systems able to compete economically with conventional power sources in dispersed applications; and the impact of major economic factors on the cost-performance index. Two major measures of the economics used are breakeven period and levelized cost of electricity (life-cycle cost). The cost-performance index was calculated for a dispersed application of a commercially available 10-kW wind-turbine generator. All-electric homes consuming 15,000 kWh annually or more have been selected for analysis. The agricultural application is represented by a commercial poultry and egg farm demanding over 92,000 kWh annually.

574/81 ENERGY RESOURCES IN KENYA AND THEIR ENVIRONMENTAL IMPACTS. C.J. Marquand and P.M. Githinji (Department of Mechanical Engineering, University of Nairobi, Nairobi (Kenya)). P. 159-77 of Energy and Environment in East Africa (Proceedings of the International Workshop on Energy and Environment in East Africa, held Nairobi, Kenya, 7-10 May 1979). ERS-3-80 (March 1980). United Nations Environment Programme, Nairobi, Kenya.

This paper reviews the different energy sources available in Kenya and their environmental impacts. It begins with a consideration of the consumption of primary sources of energy in Kenya. The environmental effects considered are for petroleum, oil, thermal power, hydropower and wood and charcoal. Other potential energy sources and their potential environmental consequences include geothermal energy, small-scale hydropower, alcohol production, nuclear energy, solar energy, wind energy, biogas energy and use of solid wastes. 16 refs.

575/81 STUDY OF THE EFFLUENTS FROM THE COMBUSTION OF SOLID WASTE MATERIAL. M.S. Massoudi (Teheran University of Technology, Teheran (Iran)). Journal of Environmental Science and Health, Part A, vol. A14, p. 629-40 (1979).

Experiments were carried out on the gasification-combustion of organic solid wastes to determine the effect of process parameters on contaminant emissions. Solid municipal waste and wood waste were gasified under reactive environments in stirred reactors. The important parameters were found to be temperature, residence time, and moisture content of the fuel. With increasing temperature, the amount of particulate matter, smoke, and hydrocarbon emissions decreased. It was found that, if the temperature exceeded 800 °C, the discharge of air pollutants from the combustion of waste material was drastically reduced. The results were then used to determine the pollution burden of applying incineration as a means of municipal-waste disposal in Teheran, Iran. 12 refs.

SELECTED ARTICLE

ENERGY, CULTURE AND HISTORY

by

Soedjatmoko
Rector, The United Nations University

Prepared for the Panel on Energy and Society sponsored by UNESCO in a series organized jointly by the United Nations Conference on New and Renewable Sources of Energy and the United Nations University, Nairobi, Kenya, 11 August 1981.

Our present global energy transition problems have forced all of us to reflect on the significance of energy for our modern civilization - and, in particular, what impact the end of the era of cheap energy is already having, and will continue to have, on our technologies, social structures, cultures and life-styles.

A look backward at history shows very clearly how our societies have evolved commensurate with man's capacity to harness additional sources of energy. One of the first anthropologists to explore the interactions between energy and culture, Leslie A. White, suggests that our cultural development is determined by "the amount of energy harnessed per capita and by the efficiency of the technological means with which it is put to work." While I personally feel that other factors must also be taken into account in measuring the advance of culture, I certainly agree with the centrality he assigns to energy in humankind's development over the millenia.

For his first hundreds of thousands of years of life on this planet, man relied primarily on the energy generated by his own muscle power to hunt and gather his food and protect himself from the elements. He conquered fire very early, but this remained an essentially unimportant energy source until the invention of the steam engine in the eighteenth century.

So too with water. While primitive man could float freight down a stream, it was only with the invention of the water wheel, shortly before the onset of the Christian era, that water became a significant energy source. Wind was not used as a source of energy until fairly recent times.

The first major transition in man's energy use came with his domestication of plants and animals. Agriculture and animal husbandry were capable of producing far more energy per capita than hunting, fishing or gathering. As the food supply grew more plentiful, populations increased, villages became towns and towns became cities - leading to the emergence of nations and empires. The state system can be attributed very directly to the Agricultural Revolution.

Methods of agriculture, irrigation techniques, and animal husbandry helped determine the directions taken by the various state systems. It was the utilization of animal traction, in combination with the heavy iron plow, that made it possible for medieval Europe to increase its agricultural production in pace with its population increase. The agricultural society that grew up, with farmland and its workers located conveniently close to the castles and manor houses, encouraged the profound social and structural changes that gave birth to feudalism.

In parts of Africa, the lack of traction animals - due largely to the pernicious effects of the Tsetse fly - made agricultural development more difficult and, at least until their recent independence, impeded the growth of large-scale social systems. In other parts of the world, large irrigation systems and their water-related technologies, led to different social and political structures. The different uses to which agricultural surpluses were put - whether serving commercial or state interests - led to further difference in the social structure, culture, and political systems among nations.

The same advances in fuel-wood-based metal-working technology which had made possible the iron plow also put iron axes and saws in the hands of the average workers, increasing their energy output and facilitating their access to the great forests of Europe, and leading to a whole material culture based on wood.

But in the end, population pressures and agricultural expansion led to deforestation of large parts of Europe. Between the thirteenth and sixteenth centuries, Europe experienced what Jeremy Rifkin has called "the last great energy watershed." Hard wood, needed for charcoal production to fuel the early phases of industrialization, was in increasingly short supply. This hastened the transition to coal and the Fuel Revolution. For the first time, man began systematically to consume the globe's non-renewable sources of energy.

As coal miners burrowed deeper and deeper into the earth, drainage pumps were needed - which spurred the development of the steam engine. Its invention, coupled with the growing inadequacy of soft roads and the canal systems to transport an increasing volume and weight of goods, led to the development of railway systems - and the Industrial Revolution.

The revolution set in motion vast transformations in the structure of society - many of them, in the short run, in no way beneficial to the urban or rural masses. A worker's life in the teeming slums of early nineteenth century London or Paris in many ways resembled that of his twentieth century counterpart in many primate cities in the Third World.

The Industrial Revolution, however, did lead generally to higher productivity - and the need for external markets for industrial goods and for imported raw materials and primary commodities. Another use of the steam engine, to power a ship, was a decisive factor in the consolidation of European colonialism, started earlier by the effective use of another form of energy, gunpowder.

In the colonies, the massive influx of industrial goods from Europe overwhelmed and destroyed local capacities in fields like textiles and iron work. As a result, the villages were reduced to mere food production units or sources of cheap plantation labour. By contrast, Japan, the single non-Western nation to have thus far joined the ranks of the affluent, was able to modernize relatively easily because it could draw on unbroken traditions of toolmaking and artisanship. Incapable of building on a similar base, the former colonies now had to industrialize through national bureaucracies, with all the problems attendant on such a situation.

It was in the context of the imperialistic setting that the exploitation and control of the new oil resources, outside the USA, passed first into the hands of the Europeans and later the Americans. From that control sprang the era of cheap energy that made possible the creation of modern mass society as we know it.

The higher productivity made possible by cheap energy triggered profound social changes. To cite but one example, women, particularly in the affluent societies, have been released from much former daily drudgery - opening up opportunities for a fuller life, greater participation and more gainful employment in society. At the same time, the mechanization of agriculture, fueled by cheap energy, has deprived women of income earning activities in many parts of the developing world.

But there are also the roots here of the present deep and untenable structural dichotomy between the affluent North and the poor South - and the centre periphery relationship which characterizes so much of the global society today.

Cheap energy has made possible the worldwide transportation and communications infrastructures which make for increasing global interdependence - even though profoundly and unacceptably assymetric - a fact of our daily lives. But they, in turn, increasingly heighten the legitimate expectations and demands of the hungry, the poor and the powerless all over the globe.

The challenge now before us, as we face the hard reality of the end of the era of cheap energy, is in finding ways for the South to fuel its own Industrial Revolution - which must come about if it is to provide jobs for its rapidly increasing millions. In Asia alone, there will be one billion more people by the dawn of the twenty-first century. If jobs are not created, the massive outflow of migrant workers, illegal immigrants, and refugees across national boundaries and into the affluent areas of the world is bound to overwhelm the regulative capacities of governments.

The pressure for jobs in the Third World over the next decade or so, resulting from a long-term lowering of the median age of its populations, could well become of explosive character. The number of young people in the Third World today is extremely disquieting - in the ASEAN nations alone we are talking about 110 million below the age of fifteen. Creating employment opportunities for the young throughout the developing world is perhaps the most perplexing and difficult problem that we face - it is bound to strain in the next two decades the political systems of many Third World countries to the utmost, whatever their ideological persuasion.

In addition, these younger generations simply will not settle for the lives of indignity and misery that their parents, in the rural countryside as well as in many urban areas, have known. They will not accept another 10 years of waiting for electricity to come their way or continue to accept the present global imbalance in energy consumption. The people of the United States and Canada use more than five times the per capita average of global energy consumption - while the peoples of South and Southeast Asia use only one-tenth of the global average. Rapid increases in energy demand in the populous, low-income countries in the Third World are inevitable.

In coping with these pressures, we will have to evolve broad-based development strategies that will ensure high growth rates but are also less energy-intensive and ecologically sustainable. Perhaps nowhere is this need so starkly vivid as in the food and energy interlinkage - with rising costs of energy threatening to drive food prices out of the reach of increasing numbers of the poor. Our best hopes here may lie in advances in the field of biotechnology: biological nitrogen fixation, genetic improvement, improvements in photosynthetic efficiency and the like. Most of these basically involve improved efficiency in our use of solar energy. But these technological advances will have to be adapted to the needs and values of small-scale farming in the populous agricultural societies who will use them. This will take time, and money, and, in particular, innovative thinking.

We need to recognize further that we are talking here essentially about the needs of some half of all humanity, living in poverty and hunger, whose daily lives are largely untouched by oil and other commercial energy sources, and most of whom rely on fuel wood and organic wastes for their basic household energy.

Thus any discussion of the energy transition problem turns inevitably to the problems of the poor. Innovative social energy systems must be developed to meet the needs of the rural poor. At the same time, the poor also need access to commercial energy, in order that industrialization can advance and that non-agricultural jobs can be created in the rural areas more rapidly. The energy available to the poor must be more than that required for mere sustenance, it must be enough to ensure development and growth.

In rethinking energy strategies, it is essential that we understand just how delicately balanced are the support systems of our planet and how much these will be affected by the activities of the hundreds of millions of poor and hungry people around the world. Problems like deforestation, soil loss, agricultural depletion and climatic change are all interconnected - and play a role in hunger and poverty. If they are not overcome, they could spawn global disruptions that no technology, no matter how ingenious or large scale, could solve.

The financial resources needed for an immense worldwide effort at improving the energy systems of the poor must inevitably turn our attention to the importance of somehow reducing the pathological spending on nuclear weapons and other arms that threaten the destruction of all humanity. We have now accumulated on this globe the destructive power equivalent to one million Hiroshima bombs - another perverse form of energy use - and we are spending some 500 billion dollars a year (about one million dollars per minute) on arms.

The efforts to resolve the energy and job creation problems of the poor and populous countries will probably lead to different trajectories of industrialization and rural modernization from those of the industrialized world. These will be less energy-intensive but equally sophisticated and may eventually lead to a variety of modern civilizations based on non-Western value configurations. These alternative modern civilizations in various parts of the world - possibly the Sinitic, Hindu and Islamic as well as others - could take their rightful place side by side with Western civilization in an interdependent world that recognizes, in a spirit of common dependence, the urgency of conserving the finite resources of this planet and using its new and renewable sources of energy to their fullest potential. Whether there will be a future for human civilization will really depend on our ability to make such a transition in energy use.

I have concentrated on the Third World because it is there, it seems to me, that the critical impact of energy on society will take place in the next few decades. However, we should remember that what happens in the industrialized countries during this period will also be of crucial importance.

Already, with the recent oil glut and price drop - which surely is only a temporary lull - we are hearing voices saying that the energy crisis has been exaggerated and that we can probably manage it without too much discomfort or change.

I think I have said enough to show how myopic and dangerous are such views. And I must emphasize that the problems of the Third World which I have outlined will become infinitely greater, and will threaten the whole fabric of our international society, if the first world does not put its own energy house in order.

Industrialized countries have the scientific and technological muscle to find ways of using energy more efficiently and to discover and exploit new sources of energy. They must use this strength. But muscle power alone will not be enough. The societies of industrialized countries now face profound ethical and moral decisions on energy.

One of the most obvious is over nuclear power and already we have seen in some countries that this is not a decision that a government - an elected government - can make alone. Further, we are beginning to recognize the need for a new kind of national and international debate as the prospect of fast-breeder reactors brings nearer the era of the plutonium society with consequences that have hardly been considered for their impact on human rights and the structures of democracy.

Another agonizing choice will be over the life-styles of the first world's consumer societies and their ever-increasing appetite for energy. How long can these be sustained? Will the inevitable change be forced on the rich countries by the poor or will we see the conscience of the industrialized world and the need for change being articulated and motivated by what I call "the movement from below" - those movements of ordinary concerned citizens which have dominated political and social life in the past twenty years and brought about many fundamental changes which were once thought politically and socially impossible.

One cannot be over-optimistic about the ability of the industrialized nations to face these issues. The problem is usually traced back to the events of 1973 - but the United States became a net importer of oil in 1947 after having been an exporter since 1870. Can it be said that these thirty-four years have been used to adjust to the inevitable consequences of that fact? In 1979 the Gallup Poll reported that 45 per cent of Americans surveyed did not know that the United States imported any oil! There is little evidence that those countries which are wholly dependent on oil imports - France, Federal Republic of Germany, Japan, for instance - have developed coherent policies in response to the inescapable consequences of this situation.

But the issues I have outlined have to be recognized by governments and peoples in all countries, rich and poor, and recognized as a single, global fact.

This recognition will shape the decisions on energy made by governments. These will be essentially political decisions - and they can have immense and far-reaching consequences. The United States decided in 1956 to launch an interstate highway system that has vastly altered American life and produced a society which uses one-third of the world's oil, most of it in the cars and trucks that use those highways. Former President Carter similarly made a political decision not to proceed with commercialization of the breeder reactor - with great implications for the future US energy "mix". The decision the world must now make is what the global energy "mix" should be - and these discussions here in Nairobi can provide much valuable input in helping us make that decision wisely and in accordance with the collective interests, hopes and aspirations of all humankind.

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

Ok
3/2/82

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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Abstracts of Selected Solar Energy Technology

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太阳能 SOLAR ENERGY СОЛНЕЧНАЯ ЭНЕРГИЯ सौर ऊर्जा ENERGÍA SOLAR সৌর শক্তি
SONNENENERGIE ENERGIA SOLAR الطاقة الشمسية 太陽エネルギー ENERGI MATAHARI
ÉNERGIE SOLAIRE सूर्य शक्ति ENERGIA SOLARE شمسیتوانائی DAYANING SURYA 태양에너지
ஞாயிற்றியலான ஆற்றல் సూర్య శక్తి دھوپ دی طاقت GÜNEŞ ENERJİSİ СОНЯЧНА ЕНЕРГІЯ
NĂNG LƯỢNG MẶT TRỜI ENERGIA SŁONECZNA સૂર્ય શક્તિ СОЛАРНА ЕНЕРГИJА ಸೂರ್ಯ ಶಕ್ತಿ
انرژی خورشیدی സൗരോർജ്ജം KARFIN HASKEN RANA ସୂର୍ଯ୍ୟ ଶକ୍ତି NISHATI YA JUA နေစွမ်းအင်
พลังงานแสงอาทิตย์ ENERHIYA NG ARAW ENERGIE SOLARĂ SOLENERGI ZONNE ENERGIE
ਸੂਰਜ ਦੀ ਸ਼ਕਤੀ دلمر انرژی SLUNEČNÍ ENERGIE ÉNESI PANON POÉ قوتِ سورج NAPENERGIA
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AMANDLA ELANGA සූර්ය රශ්මි බලය ҚУЁН ЭНЕРГИЯСИ گعون انرژیسی ΗΛΕΙΑΚΗ ΕΝΕΡΓΕΙΑ
ENERHIYA SA ADLAW سج جي قوتُ **የፀሐይ ፡ ኀይል** СЛЪНЧЕВА ЕНЕРГИЯ SUNČANA ENERGIJA
ENÈGI SOLÈY **ሀ·ምና ፡ እዱ** ថាមពល ព្រះអាទិត្យ KOWADDA PANASSA AREH HERIN'NY MASOANDRO
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MATLA A LETSATSI CUARAJHY MBARETÉ KATAN U JANTE BI

THE UNITED NATIONS UNIVERSITY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy for Rural Communities Sub-programme of the Programme on the Use and Management of Natural Resource of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

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THE UNITED NATIONS UNIVERSITY
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INTRODUCTION

The Programme on the Use and Management of Natural Resources of the United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

- A. General
- B. Solar Energy
  - B1 Radiation Measurement
  - B2 Photovoltaic Conversion
  - B3 Active Thermal Systems
  - B4 Passive Thermal Systems
- C. Bioconversion Energy
  - C1 Biomass Production and Conversion
  - C2 Biogas Production and Utilization
- D. Wind Energy
- E. Energy Storage
- F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Scientists and engineers in developing countries who wish to participate in this information network and receive ASSET regularly may do so free of charge. ASSET is available in industrialized nations at an annual subscription rate of US$25 by sea mail and US$40 by air mail payable by check, money order, bank draft or UNESCO book coupons to the United Nations University. ASSET has published lists of the names and addresses of all members of the network as of 1 December 1980 in vol. 1, no. 12 (1979) and vol. 2, no. 10 (1980).

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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ABSTRACTS

A. GENERAL

576/81 ENERGY AND DEVELOPMENT: THE CASE OF KENYA. D. Shakow, D. Weiner and P. O'Keefe. Ambio, vol. 10, no. 5, p. 206-10 (1981).

This article examines the current energy situation in Kenya with a particular emphasis on the traditional, non-commercial sector. While there is presently an energy crisis in the commercial sector (precipitated by the rapid escalation of oil prices) there is another more sinister energy crisis that confronts millions of people in developing countries - the scarcity of fuelwood and charcoal. 5 refs.

577/81 AN INDIAN VILLAGE AGRICULTURAL ECOSYSTEM - CASE STUDY OF UNGRA VILLAGE, PART I: MAIN OBSERVATIONS. N.H. Ravindranath, S.M. Nagaraju, H.I. Somashekar, A. Channeswarappa, M. Balakrishna, B.N. Balachandran and A.K.N. Reddy (ASTRA, Indian Institute of Science, Bangalore 560012 (India)). Biomass, vol. 1, p. 61-76 (1981).

The South Indian agricultural village of Ungra (population - 932, households - 149, total area - 360.2 ha) has been studied as an ecosystem with a special emphasis placed on the production of biomass and its utilization by humans and livestock. Following a description of methodology, the main results of the ecosystem study are presented. In particular, a quantitative report is given of the land use and cropping patterns, the above-ground plant biomass productivities, the disaggregation of the plant biomass into various components and their subsequent utilization, the food consumption by human beings and livestock, the materials and energy flow through the ecosystem, and the village's imports and exports. 6 refs.

578/81 AN INDIAN VILLAGE AGRICULTURAL ECOSYSTEM - CASE STUDY OF UNGRA VILLAGE, PART II: DISCUSSION. A.K.N. Reddy (ASTRA, Indian Institute of Science, Bangalore 560012 (India)). Biomass, vol. 1, p. 77-88 (1981).

The observations reported in Part I of this paper are discussed in detail here. It has been argued that the agricultural village of Ungra is an open, dependent, land-humans-livestock ecosystem. Simple expressions have been derived for the carrying capacity of the ecosystem with respect to cereal crops, the ratio of crop land to pasture land, the number of draught animals, the ratio of humans to draught animals and the human-to-cattle ratio. The agreement between the calculated and observed parameters has been taken as evidence that there is a rationale underlying the ecosystem. The energy aspects of the ecosystem (in particular draught power and cooking fuel) have been discussed in terms of enhancing the productivity and/or self-sufficiency of the ecosystem. Some of the important limitations of the study have been identified in order to indicate the directions of recent work. It has been concluded that an understanding of the logic of village agricultural ecosystems should be the basis of rural development. 3 refs.

579/81 INTEGRATED ENERGY SYSTEM FOR NON-ELECTRIFIED RURAL COMMUNITIES. A.M. Martinez, E. Caldera, N. Puga, M. Mandujano, F. Santander, A. Felix, S. Sanchez, A. Wong, S. Valverde, P. Mulas, A. Castellanos, M. Escobedo and I. Restrepo (Instituto de Investigaciones Eléctricas, Cuernavaca (Mexico)). P. 1964-73 of Proceedings of the International Conference on Energy Use Management (held Los Angeles, CA, USA, 22 Oct. 1979). Pergamon Press, New York, NY, USA.

Local renewable energy resources may be used for productive activities in rural non-electrified communities. Biomass, solar, wind and micro-hydraulic systems can be combined to form an integrated energy system in which only technologies that are not too expensive or too technically sophisticated for easy maintenance are considered. The socio-economic aspects involved in the implementation of such a system are considered very important and an example of a proposed pilot community is presented. 11 refs.

580/81 APPROPRIATE TECHNOLOGY IN AFRICA. M. Anderson. Solar Age, vol. 4, no. 5, p. 42-5 (May 1979).

A study and the implementation of appropriate energy technology in Botswana, Swaziland, and Lesotho was conducted by the Domestic Technology Institute and the Inter-Culture Associates. The needs and problems identified in these African countries included inadequate diets, lack of firewood and accessibility to water, poor lighting, water-related diseases, fluctuating indoor temperatures, exposure to smoke and burns from open fires, agricultural difficulties, and parasitic illnesses. Renewable-energy technologies cited as appropriate for some of these problems included grow-hole underground greenhouses, thatch insulation, improved wood stoves, bread-box solar water heaters, thermosyphon solar cookers, wind-power systems, small-scale hydro systems, ethanol fuel and pyrolysis. The materials, training and implementation schemes for these technologies are described.

581/81 THE FUTURE OF RENEWABLE ENERGY IN DEVELOPING COUNTRIES. G. Foley (International Institute for Environment and Development, London (UK)). Ambio, vol. 10, no. 5, p. 200-5 (1981).

Despite the evident need for energy in developing countries, renewable-energy technologies (apart from large-scale hydropower and firewood) have not yet found a significant role. This paper analyses their potential in the commercial-industrial sector, the subsistence sector, and the rural transitional sector. The analysis is placed in the context of the UN Conference on New and Renewable Sources of Energy. It also points out the danger of over-valuing renewable energy sources and imposing a prejudiced view upon energy policy-making in developing countries. 17 refs.

582/81 RURAL ENERGY NEEDS AND ALTERNATIVE SOURCES. G. Muchiri (Department of Agricultural Engineering, University of Nairobi, Nairobi (Kenya)). P. 323-49 of Energy and Environment in East Africa (Proceedings of the International Workshop on Energy and Environment in East Africa, held Nairobi, Kenya, 7-10 May 1979). ERS3-80 (March 1980). United Nations Environment Programme, Nairobi, Kenya.

Rural development and basic needs form the background of this paper which emphasizes the energy situation in Kenya. Assuming no drastic changes take place, the results of energy consumption trends in Kenya are examined. Possible alternative sources of energy for rural areas and the policies to promote the development of such sources are also discussed. The sources examined are: biomass, pyrolysis, biogas generation, alcohol production, wind power, solar energy (including thermodynamic and photovoltaic systems), and small-scale hydroelectric generation. 16 refs.

B. SOLAR ENERGY

583/81 PERSPECTIVE ON DEVELOPING COUNTRY SOLAR ENERGY APPLICATIONS. R. Ramakumar and J.C. Beavers (School of Electrical Engineering, Oklahoma State University, Stillwater, OK 74074 (USA)). P. 93-8 of Proceedings of the Fourteenth Intersociety Energy Conversion Engineering Conference (held Boston, MA, USA, 1979). American Chemical Society, Washington, DC, USA (1979).

Several fundamental questions concerning the inventories of renewable energy resources useful in the development of rural areas in developing nations are discussed. 32 refs.

584/81 INTERNATIONAL COOPERATION WITH DEVELOPING COUNTRIES (発展途上国との国際協力について). Takemura M. Taiyō Enerugī (Solar Energy), vol. 6, no. 3, p. 35-7 (1980). In Japanese.

The possibilities of solar energy utilization in developing countries and the potential of co-operation between Japan and these countries are described. The basic concept of solar energy utilization in developing countries is different from that of industrialized countries due to specific climatic conditions. The most developed aspect of solar energy utilization in Japan is its application to solar heating, cooling and hot-water supply for buildings. The application of solar energy to agriculture is most important in developing countries. Libya plans to irrigate her spacious desert regions by well water using solar-powered pumps. Venezuela plans to use solar energy for process heat and for power generation (which requires high temperatures of 300 - 400 °C). Some examples of the practical applications of solar energy systems in these countries are also described.

585/81 SOLAR ENERGY, WATER AND INDUSTRIAL SYSTEMS IN ARID LANDS: TECHNO-ECOLOGICAL OVERVIEW AND ANNOTATED BIBLIOGRAPHY. C.P. Duffield (Office of Arid Lands Studies, University of Arizona, Tuscon, AZ 85721 (USA)). Arid Lands Resources Information Paper, No. 12 (1978). Office of Arid Lands Studies, University of Arizona, Tucson, AZ, USA. 151p.

Techno-ecology is described as the study of large complex industrial systems in a manner analogous to the analysis of biological ecosystems. This study serves as a framework within which diverse solar energy technologies can be holistically comprehended and managed. Solar energy systems and sun-powered bio-ecosystems are seen to have many parallels at the organizational and ecosystem levels, with solar collectors being analogous to plants in design, organization and adaptation to arid conditions. Solar technologies for water processing (pumps, drainage, storage conservation and desalination and evaporation) and use (solar energy collection, storage, distribution; cooling; and helio-hydroelectric and salinity gradient power plants) are reviewed. It is seen that the complex symbiosis of solar and water technologies may prove advantageous. Large solar energy systems could counteract desertification and atmospheric CO_2 increases. Solar energy technologies are seen to be vital to the future survival of arid, oil-rich countries with their use in other developing countries also of importance at the appropriate scale. 100 abstracts are included in the bibliography. 133 refs.

586/81 SOLAR ENERGY FOR AGRICULTURE: REVIEW OF RESEARCH. W.K. Trotter, W.G. Heid, Jr. and R.G. McElroy (Department of Agriculture, Washington, DC (USA)). ESCS-67 (Aug. 1979) 29p. NTIS.

Research underway on solar energy use for various agricultural applications is reviewed: grain drying, heating and cooling of greenhouses and rural residences, heating of livestock shelters, drying crops other than grain, food processing, and irrigation. Solar energy systems for agriculture are in an early stage of development and this study makes an exploratory economic assessment of current and prospective solar energy technologies.

587/81 SPECTRALLY SELECTIVE COPPER SULPHIDE COATINGS. S.B. Gadgil, R. Thangaraj, J.V. Iyer, A.K. Sharma, B.K. Gupta and O.P. Agnihotri (Department of Physics and Center of Energy Studies, Indian Institute of Technology, New Delhi 110016 (India)). Solar Energy Materials, vol. 5, p. 129-40 (1981).

Copper sulphide films were chemically deposited on aluminium substrates and their optical properties were studied in relation to their application to the photothermal conversion of solar energy. The films were stable, had good adhesive properties, were fairly uniform and were also found to possess spectral selectivity. The maximum solar absorptance ($\alpha_s = 0.89$) and minimum thermal emittance ($\varepsilon_t = 0.25$) were found for films deposited at 250 °C and having a thickness of 1.6 µm. The selective coating gave a stagnation temperature of 124 °C, which is an improvement in collector efficiency of 17% over black paint. The films were found to be stable up to 200 °C. Different aging tests such as temperature stability, temperature cycling and ultraviolet irradiation have been completed. The films essentially provide low-cost selective coatings for photothermal conversion of solar energy. The cost of the coating per square meter has been estimated to be around US$2.5. 9 refs.

588/81 SELECTIVE TRANSPARENT FILTERS PRODUCED BY OPTICAL MULTILAYER COATINGS. Yoshida S. and Misawa S. (Electrotechnical Laboratory, Denshi Gijutsu Sōgō Kenkyūjo, Nagata-cho, Chiyoda-ku, Tokyo (Japan)). Bulletin of the Electrotechnical Laboratory (Denshi Gijutsu Sōgō Kenkyūjo Ihō), vol. 144, nos. 1-2, p. 98-108 (1980). In Japanese.

As transparent filters for solar-thermal collectors, anti-reflection coatings of MgF_2 on glass and selective transparent filters, consisting of a thin metal film sandwiched between dielectric layers on glass, were fabricated by vacuum evaporation. The coating of MgF_2 anti-reflection layers on both sides of Pyrex glass increases the solar transmittance from 0.901 to 0.924. Selective transparent filters of $TiO_2/Ag/TiO_2$, $ZnS/Ag/ZnS$ and $CeO_2/Ag/CeO_2$ on Pyrex glass have transmittances higher than 90% in the visible, and reflectances higher than 90% in the infrared. However, their high-transmittance bands are rather narrow. Effects of the filters are evaluated by comparison between the thermal efficiencies of the solar collectors with and without the selective transparent filter. 16 refs.

589/81 ALUMINIUM OR COPPER SUBSTRATE PANEL FOR SELECTIVE ABSORPTION OF SOLAR ENERGY. M.L. Roberts, M.H. Sharpe and A.C. Krupnick (to National Aeronautics and Space Administration). US Patent 4,177,325 (4 Dec. 1979). File date: 30 May 1978. 8p.

A panel for selectively absorbing solar energy is disclosed comprising an aluminium substrate, a layer of zinc thereon, a layer of nickel over the zinc layer and an outer layer of solar energy-absorbing nickel oxide. Another panel uses a copper substrate with a layer of nickel thereon and a layer of solar energy absorbing nickel oxide distal from the copper substrate. A method for making such panels is disclosed.

590/91 A NEW APPROACH TO LOW COST LARGE AREA SELECTIVE SURFACES FOR PHOTOCHEMICAL CONVERSION. K.B. Gupta, F.K. Tiwari, O.P. Agnihotri and S.S. Mathur. Energy Research Report, vol. 3, p. 371-7 (1979).

In the present study, selective black-paint coatings were prepared by coating reflective metal particles with a layer of selective black materials. The coated particles were mixed in a binder and easily applied as a thin layer onto aluminium or galvanized iron sheet. Three selective black materials (CuO, CuS and PbS + CuS) were deposited on zinc metal powder. The solar absorptance of the coatings is about 0.95 and the emittance is about 0.4. The thickness of the coatings is about 20 to 30 µm. The emissivity decreases as the thickness increases, while the solar absorptivity does not change appreciably. The improvement in the collector efficiency (the ratio of the collector's temperature to the ambient temperature) is estimated to be around 11%. The process is potentially a low-cost one for large-scale applications in solar photothermal conversion.

591/81 FUNDAMENTALS AND TECHNIQUES OF NON-IMAGING OPTICS FOR SOLAR ENERGY CONCENTRATION. FINAL REPORT. R. Winston (University of Chicago, IL (USA)). DOE/ER/04657-2 (20 May 1980) 51p. NTIS. US$10.50.

Non-imaging optics is a new discipline with techniques, formalism and objectives quite distinct from the traditional methods of focusing optics. These new systems achieve or closely approach the maximum concentration permitted by the Second Law of Thermodynamics for a given angular acceptance and are often called ideal. Application of these new principles to solar energy systems over the past seven years has led to the invention of a new class of solar concentrators, the most well known version of which is the Compound Parabolic Concentrator (CPC). A new formalism for analysing non-imaging systems in terms of a quantity called the geometrical vector flux has been developed. This has led not only to a better understanding of the properties of ideal concentrators but to the discovery of several new concentrator designs. One of these new designs, referred to as the trumpet concentrator, has several advantageous features when used as a secondary concentrator for a point-focusing dish concentrator. A new concentrator solution for absorbers which must be separated from the reflector by a gap has been investigated: for example, Compound Elliptical Concentrators (CEC) as secondary concentrators and asymmetric ideal concentrators. A thermodynamic model which explains quantitatively the enhancement of effective absorptance of graybody receivers through cavity effects has been developed. The classic method of Liu and Jordan, which allows one to predict the diffuse sunlight levels through correlation with the total and direct fraction, was revised (updated) and then applied to predict the performance of non-imaging solar collectors. The conceptual design for an optimized solar collector which integrates the techniques of non-imaging concentration with evacuated tube collector technology was carried out.

B1. RADIATION MEASUREMENT

592/81 INEXPENSIVE, PORTABLE, INTEGRATING SOLAR ENERGY METER. R.M. Masters (Lewis Research Center, Cleveland, OH (USA)). Energy Tech Notes, vol. 80, no. 2 (Feb. 1980) 2p.

An insolation recorder is described which incorporates a single silicon solar cell whose output is amplified and integrated, and measured via a voltage-to-frequency converter, divider and counter. Measured intensities (Wh/m^2) are displayed on a digital mechanical counter. Via a digital-to-analog converter and chart recorder, a time history of insolation can also be recorded. The instrument is battery operated.

B2. PHOTOVOLTAIC CONVERSION

593/81 HIGH-EFFICIENCY InP HOMOJUNCTION SOLAR CELLS. G.W. Turner, J.C.C. Fan and J.J. Hsieh (Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA 02173 (USA)). Applied Physics Letters, vol. 37, no. 4, p. 400-2 (1980).

Conversion efficiencies up to 15% (AM1) have been obtained for antireflection-coated InP homojunction solar cells, the highest efficiency values reported for InP cells of any type. The cells were fabricated on $n^+/p/p^+$ structures formed by liquid-phase epitaxy on single-crystal InP substrates. The cell photovoltaic characteristics are not very sensitive to n^+-layer thickness, indicating that the surface recombination velocity is not as high as in homojunction GaAs solar cells. The performance of various antireflection coatings has been investigated. 14 refs.

594/81 HIGH EFFICIENCY $Al_xGa_{1-x}As$-GaAs SOLAR CELLS WITH HIGH OPEN-CIRCUIT VOLTAGE AND HIGH FILL FACTOR. Yoshida S., Mitsui K., Oda T., Sogo T. and Shirahata K. (Semiconductor Laboratory, Mitsubishi Electric Corp., Hyōgo (Japan)). Vol. 19, sup. 19-1, p. 563-6 of Proceedings of the Conference on Solid State Devices (1980).

p-$Al_xGa_{1-x}As$/p-GaAs/n-GaAs solar cells were fabricated by liquid-phase epitaxial growth of Zn-doped $Al_xGa_{1-x}As$ on (111)B n-GaAs substrates. High conversion efficiencies of about 21% (AM1.4), with a high open-circuit voltage (1.00 - 1.01 V) and a high fill factor (0.82 - 0.84), were reproducibly obtained together with a reduction in the dark current. This was realized by driving the p-n junction depth (width of the p-GaAs region) about 3 - 5 μm below the $Al_xGa_{1-x}As$-GaAs interface. The p-n junction was controlled by varying the time during which a substrate was soaked isothermally in the saturated Al-Ga-As Zn-doped melt at a fixed Zn content. 6 refs.

595/81 HIGH EFFICIENCY SILICON CELLS FOR LUMINESCENT SOLAR CONCENTRATORS. C.M. Garner, F.W. Sexton and R.D. Nasby (Sandia National Laboratories, Albuquerque, NM 87115 (USA)). Solar Cells, vol. 4, p. 37-46 (1981).

Energy-conversion efficiencies of 18 and 19.4% at 0.1 and 1 W cm^{-2}, respectively, were measured for a luminescent solar concentrator cell under an AM1 solar spectrum. This cell was designed for operation under an illumination of 600-nm wavelength and 1 W cm^{-2}. From these results and spectral-response data, an efficiency of 26% can be projected for an illumination at 600 nm. This agrees well with computer code calculations of 28%. The substrate doping level, cell grid pattern, minority-carrier lifetime and antireflection coating properties were studied to optimize the cell performance for 600-nm (and longer) wavelengths. 12 refs.

596/81 PHOTOVOLTAIC PROPERTIES OF THIN FILM Cu_2Se-CdSe HETEROJUNCTIONS. J.K. Kim. Journal of Natural Science, College of General Education, Seoul National University, vol. 7, no. 1, p. 57-62 (1976). In Korean.

In order to convert solar energy directly into electrical energy, photovoltaic cells of a Cu_2Se-CdSe heterojunction structure have been fabricated by a continuous flash-evaporation method for CdSe and by a wet method for the Cu_2Se layer.

597/81 SILICON SOLAR CELLS. II. PRACTICAL ASPECTS. R.E. Thomas (Carleton University, Ottawa, Ontario (Canada)). P. 805-30 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York, NY, USA (1979).

Areas in which significant improvements have been made in the efficiency of single-crystal silicon solar cells are discussed. Examples of the current status of the development of low-cost materials for solar cells and the realization of solar cells for terrestrial applications by cheap, energy-conserving automated techniques are cited. Alternative approaches to diffused junctions are discussed. 41 refs.

598/81 PERFORMANCE OF A PHOTOVOLTAIC CONCENTRATION MODULE CONSISTING OF SILICON SOLAR CELLS WITH A FACET CYLINDRICAL MIRROR COSS. R. Bomal and P. Ragot (Commissariat à l'Energie Atomique, Département des Etudes Mécaniques et Thermiques, Service d'Etudes Energétiques, Centre d'Etudes Nucléaires, Saclay 91191 Gif-sur-Yvette, Cédex (France)). Solar Cells, vol. 4, p. 91-100 (1981)

A concentration device using silicon solar cells functioning under a sunlight concentration of up to 50 suns is described. The solar cells are located on the optical focal line of a faceted cylindrical concentrator mirror COSS (Capteurs optiques solaires segmentés), of the same type as the device used for the 100-kW_e French solar power plant in Corsica (COSS type). This concentrator consists of reflecting plane facets located around the axis of a cylindrical surface. The rays of light reflected from each elementary mirror converge to a focal surface centred around the axis of the cylinder. The mirror device is fixed with an east-west orientation. The method of concentration exhibits some distinct advantages over classical optics for photovoltaic conversion: (a) simplified tracking owing to the slow and simple rotation of the linear focal axis about which the photocells are located; (b) image-free optics; (c) an inexpensive structure (mirror and tracking) for series fabrication; and (d) easily exportable fabrication technology. An 18-m^2 mirror prototype was used to test a device consisting of 48 Radiotechnique Compelec solar cells provided by the Commissariat à l'Energie Solaire, Paris, France. This generator device supplies 33 W of peak power for a cell area of 192 cm^2. The cells are water cooled. The system is described and the results obtained are given. 3 refs.

599/81 THE SILICON CONCENTRATOR PHOTOVOLTAIC GENERATOR SOPHOCLES: PERFORMANCE AND COSTS BASED ON MATERIAL CHARACTERISTICS. D. Esteve, G. Vialaret and F. Therez (Laboratoire d'Automatique et d'Analyse des Systèmes, 7 Avenue du Colonel Roche, 31400 Toulouse (France)). Solar Cells, vol. 4, p. 47-59 (1981).

The purpose of this paper is to show that in the short term a solution can be found to enable the immediate exploitation of concentrator photovoltaic systems. The technical requirements, tracking system, optical system and thermal dissipation necessary for concentrator generators are described. A description of the prototype generator Sophocles built in this laboratory is also presented and the results of various experiments are given. Finally, a review of the prospects for reduction in cost for a concentrator generator using a higher concentration ratio and more efficient solar cells, which can lead to a price of \$4 W_p^{-1} if all expenses are taken into account, is presented. 11 refs.

600/81 FLUORESCENT PLANAR COLLECTOR-CONCENTRATORS: A REVIEW. A. Goetzberger and V. Wittwer (Fraunhofer-Gesellschaft Arbeitsgruppe für Solare Energiesysteme, Oltmannsstrasse 22, D-7800 Freiburg (Fed. Rep. of Germany)). Solar Cells, vol. 4, p. 3-23 (1981).

Fluorescent planar collector-concentrators are a new idea for the conversion of solar energy into electrical and thermal energy. The collection and concentration of direct and diffuse radiation is possible by using a stack of transparent sheets of material doped with fluorescent dyes. In combination with photovoltaic cells, this type of collector offers the advantage of separating the various wavelengths of light and converting them using solar cells with different band gaps. Theoretical models of the system, the efficiency, the real collector properties and the experimental results are reviewed. 19 refs.

601/81 TRANSFORMATION OF SOLAR RADIATION BY FLUORESCENCE: APPLICATION TO THE ENCAPSULATION OF CELLS (TRANSFORMATION DU RAYONNEMENT SOLAIRE PAR FLUORESCENCE: APPLICATION A L'ENCAPSULATION DES CELLULES). D. Sarti, F. le Poull and P. Gravisse (Laboratoire Bric, 113 Chemin de Ronde, 78290 Croissy-sur-Seine (France)). Solar Cells, vol. 4, p. 25-35 (1981). In French.

The presence of fluorescent material, associated with a "cascade of light" in the polymethylmethacrylate (PMMA) which can be used to coat silicon solar cells, allows an increase of 25% in the conversion efficiency of photovoltaic modules. This is due to two effects: (1) a better match between the incident radiation and the solar cell spectrum and (2) the concentration of radiation due to the total internal reflections in the PMMA matrix. 11 refs.

La présence de substances fluorescentes, associées en "cascade lumineuse" dans la résine polyméthylmétacrylate (PMMA) enrobant les cellules solaires au silicium, permet d'accroître de 25% le rendement de conversion des modules photovoltaïques. Ceci est dû à deux effets: (1) une meilleure adaptation spectrale entre le rayonnement incident et la sensibilité de la cellule solaire; (2) une concentration du rayonnement par réflexions totales internes dans la matrice de PMMA. 11 réf.

602/81 LUMINESCENT SOLAR CONCENTRATOR (LSC): A DIFFUSE SUNLIGHT CONCENTRATOR FOR SOLAR CELLS. G.W. Vincent (Oregon Graduate Center, Beaverton, OR (USA)). P. 41-3 of Proceedings of the Solar '79 Northwest Conference (held Seattle, WA, USA, 10 Aug. 1979). CONF-790845. NTIS. US$33.00 for complete proceedings.

A luminescent solar concentrator is a nontracking device which can concentrate direct and diffuse sunlight onto solar cells for electricity generation. An additional advantage is that it has a greater efficiency on a cloudy day than on a sunny one. The fundamentals of LSCs are discussed along with their limitations. Finally, a design is presented for a recently constructed collector that should help in overcoming some of the limitations of LSCs.

B3. Active Thermal Systems

603/81 MODIFICATION OF THE INTAKE-EXHAUST SYSTEM OF A MGS 2 x 1000 EXPANSION MOTOR IN A SEGAL SOLAR PUMP (MODIFICATION DU SYSTEME ADMISSION-ECHAPPEMENT DU MOTEUR A EXPANSION MGS 2 x 1000 EQUIPANT LA POMPE SOLAIRE SEGAL). M. Bremont, D. Fall, E. Guennec and G. Madon (Institut Universitaire de Technologie, Dakar (Senegal)). Université de Dakar, Annales de la Faculté des Sciences, vol. 31, p. 33-37 (1978). In French.

This article describes the modifications of the intake and exhaust systems of the MGS 2 x 1000 solar motor in an attempt to reduce excess space. Tests using the modified motor with a SEGAL pump are reported. 5 refs.

Cet article décrit les modifications du système admission-échappement du moteur solaire MGS 2 x 1000 conçues pour en réduire l'encombrement. Les tests ont été effectués sur le moteur modifié, avec une pompe SEGAL. 5 réf.

604/81 HEATING OF THE SOLAR ORIENTATED GREENHOUSE BY MEANS OF SOLAR AIR HEATER AND SOLAR POND AND THE PROCUREMENT OF THE GREENHOUSE HUMIDITY THROUGH SPECIAL FILM. A. Vatansever (Turkish Solar Energy Research Foundation, Istanbul (Turkey)). P. 373-83 of Tagungsbericht des Dritten Internationalen Sonnenforums (Proceedings of the Third International Solar Forum, held Hamburg, Fed. Rep. of Germany, 24 June 1980). DGS-Sonnenenergie Verlag, München, Fed. Rep. of Germany (1980).

When a plant is planted it must be in a warm and humid environment. For this purpose, water heated in a solar pond is circulated in plastic tubes which are buried at a depth of 25-30 cm in the greenhouse soil. In order to maintain the humidity of the soil (which has been heated to 15 or 20 °C) between 30 and 70%, a perforated film cover is used. By preserving the oxygen and CO_2 balance within the greenhouse, by maintenance of the vegetation, earlier and greater production can be realized.

605/81 EXPERIMENTAL INVESTIGATIONS OF AN INTERMITTENT AMMONIA-WATER SOLAR REFRIGERATOR. A. Venkatesh and M.C. Gupta (Indian Institute of Technology, Madras (India)). P. 675-84 of Proceedings of the National Solar Energy Convention (held Bhavnagar, India, 20-22 Dec. 1978). Central Salt and Marine Chemicals Research Institute, Bhavnagar, India (1978).

This paper discusses the experimental results of an intermittent ammonia-water solar refrigerator operating with a flat-plate collector. Results obtained from experiments conducted in the initial concentration range of 0.5 to 0.65 are compared and discussed. Also, the effects of cooling load, rate of cooling of the absorber and the use of mirror boosters on the performance of the refrigerator are discussed.

606/81 SOLAR-HEATED GRAIN DRYER FOR THE TROPICS. V.G. Gayanilo, C.J. Bern and G.L. Kline (Iowa State University, Ames, IA (USA)). Paper presented at the Winter Meeting of American Society of Agricultural Engineers (held New Orleans, LA, USA, 11 Dec. 1979). ASAE Technical Paper No. 79-3528 (1979) 35p. ASAE, St. Joseph, MI, USA.

The performance of a simple low-cost solar-heated grain-drying system for use in the tropics was investigated. Studies included an evaluation of: the collector's performance; the utilization of engine waste heat and the economic feasibility of the drying system. A bare-plate solar heat collector was found to be capable of contributing as much as 60% of the total heat added to the system. High airflow and insolation rates resulted in higher collection efficiencies and useful heat gain in the collector. Collector length was also found to have a significant effect on the temperature rise in the collector. Available waste heat from the dryer fan engine represented a significant source of heat energy for the grain-drying system. The solar-heated grain-drying system supplemented by engine waste heat is cable of drying a load of wet corn grains from 26.3 to 13.9% moisture content, wet basis, in 12 hours covering 1.5 days. It is also expected that drying time under tropical conditions would be less on account of higher insolation rates. 29 refs.

607/81 ROLL-UP DEVICE TO GENERATE USEFUL HEAT FROM SOLAR RADIATION. E. Grundmann, R. Kroll and H. Heitland (to Volkswagenwerk A.G., Wolfsburg (Fed. Rep. of Germany)). Fed. Rep. of Germany Patent 2,515,398/C/ (23 Nov. 1978) 2p. In German.

A solar collector which can be rolled up is described. It is unique in that it is built in such a way that there is a separation between the heat-receiving medium and the medium which delivers the heat for consumption. A black-coloured absorbing foil is not only connected on one side with a transparent foil forming a flow duct, but another flow duct is formed by means of a foil on that side of the black foil which is turned away from the sun. Thus, the whole system works like a heat exchanger.

608/81 SOLAR ENERGY COLLECTOR DEVICE. C.G. Acosta. NSDB Technology Journal, vol. V, no. 4, p. 42-4 (1980).

A novel solar energy collector is described comprising: a rectangular housing with a plurality of longitudinal V-shaped reflectors; a top cover forming an arcuate shape held securely within the housing by means of screws along its opposite sides; a heat absorber comprising a series of longitudinal copper flat-black coated tubes arranged with a plurality of sections extending in a parallel relation and connected at the ends thereof by return bend portions; a pair of return tubes rigidly connected on each end of the absorber through which helium gas is adapted to circulate within the heat exchanger and the collector; and a check valve provided at the inlet portion of the return tube to prevent gas from flowing back to the heat exchanger.

609/81 APPARATUS FOR THE COLLECTION AND CONVERSION OF SOLAR ENERGY. A.L. Korr, E.H. Walker and B.T. Svihel (to A.L. Korr Associates, Inc.). US Patent 4,159,629 (3 July 1979). File date: 30 Mar. 1977. 14p.

Solar energy is collected by an array of parallel trough-like reflectors of paraboloidal cross-section, and concentrated upon radiation-absorbent pipes positioned along the lines of focus of the reflectors. The array is mounted on a boat which floats on an irrigation pond of a farm and is rotated by a clock-like drive mechanism so as to follow or track the daily east-west motion of the sun, thereby maintaining the concentration of solar radiation upon the pipes. The flotation of the array by means of the boat permits the use of very low drive power, and also shields the underlying water from the air and sun so as to reduce evapouration thereof. A central column stabilizes the position of the boat with respect to lateral drift or angular tilt while permitting vertical motion of the boat in response to changes in pond level. The array may therefor be protected from heavy wind by dropping the pond level so that the array is protected by the sidewalls of the pond at such times. A rotating joint arrangement permits circulation of a heat-absorbent fluid such as water (steam) between the radiation-absorbent pipes and a location adjacent the pond were the developed heat is utilized.

610/81 COMPARATIVE PERFORMANCE TESTING OF FLAT-PLATE SOLAR WATER HEATERS. K.S. Ong (University of Malaya, Kuala Lumpur (Malaysia)). Vol. 2, p. 993-7 of Sun: Mankind's Future Source of Energy (Proceedings of the International Solar Energy Congress, held New Delhi, India, 16-21 Jan. 1978). F. de Winter and M. Cox (eds.). Pergamon Press Inc., Elmsford, NY, USA (1978).

A simple experimental test facility was set up to compare the outdoor performances of various flat-plate solar-heat collectors operating under a once-through flow cycle. Simultaneous side-by-side tests were conducted on various collectors to demonstrate the effectiveness of the apparatus. The effects of providing single glazing, double glazing and a bank of horizontally-laid fluorescent light tubes as a collector cover and using copper or aluminium as collector plate material were investigated. 7 refs.

611/81 DEVELOPMENT OF A LOW-COST NON-TRACKING HEAT PIPE CONCENTRATING COLLECTOR. K.K. Feldman, Jr. and D.L. Noreen (New Mexico Energy Institute, New Mexico State University, Las Cruces, NM (USA)). NMEI-23 (July 1979). New Mexico Energy State University, Las Cruces, NM, USA. 158p.

A solar water heater which uses a multi-heat-pipe energy absorber is proposed. In the absorber configuration, wickless heat pipes (which rely on only gravity) and a puddle-flow mechanism are used. In order to design an energy absorber with sufficient heat-transfer capability, the performance of a puddle-flow gravity-assisted heat pipe had to be theoretically investigated. Three low-temperature heat-pipe working fluids were considered in this analysis and the maximum heat-transport capability of methanol, water, and Freon-11 heat pipes was investigated. The relationship between various heat-pipe parameters and axial heat-transport capability is discussed. To determine the performance of a solar water heater which uses a multi-heat-pipe energy absorber, a theoretical model is developed and experimentally validated. The collection efficiency is found to vary markedly with the number of energy-absorber heat pipes, coating emittance, and the ambient-weather cycle.

612/81 CHARACTERISTICS OF 3.5 m LONG HEAT PIPE FOR SOLAR COLLECTOR. Ezawa N., Tanaka T. and Shimizu S. Denki Shikensho Iho, vol. 43, no. 1-2, p. 37-43 (1979). In Japanese.

Heat pipes (3.5-m long) were designed and fabricated, and their operating characteristics were experimentally examined to determine their effectiveness as solar energy collectors. Long heat pipes were found to have a heat-transfer efficiency and coefficient of more than 90% and on the order of 10^3(kcal/m^2-h-°C), respectively.

613/81 RECENT HEAT PIPE APPLICATIONS AT THE CEN, GRENOBLE, FRANCE. J.D. Montmayeur. Revue Générale de la Thermodynamique, vol. 18, no. 208, p. 223-7. (April 1979). In French.

Present industrial applications of heat pipes are reviewed, e.g., cooling of thermoplastic material or aluminium molds with heat pipes coupled to cooling systems or heat diffusion in the mold via the heat pipe; heat extraction in latent heat-of-fusion storage; thermal link between solar collectors and storage; cooling of internal-combustion engine valves; and heat-pipe ovens and heating plates.

614/81 METHANOLCALCIUM CHLORIDE CHEMICAL HEAT PUMP FOR SOLAR AIR CONDITIONING, HEATING, AND STORAGE. P.O. Offenhartz (EIC Corporation, Newton, MA (USA)). P. 603-7 of Proceedings of Solar Energy Storage Options Workshop (held San Antonio, TX, USA, 18 Mar. 1979). NTIS. US$51.50 for complete proceedings (CONF-790328-P1 and P2).

The EIC chemical heat-pump system based on $CaCl_2$ and CH_3OH is designed to provide solar air conditioning, space, and domestic water heating, and thermal storage in a single unit. Furthermore, as a thermally activated heat pump it is designed to amplify the solar collector output, providing more heat than is collected. Unlike electrically powered heat pumps, the system relies primarily on solar energy to perform the heat-pumping work, so the electrical requirements are quite modest: no compressor is involved. This system is capable of pumping heat up to a 45 C° temperature gradient, so it can be used in the air-conditioning mode without the need for an evapourative heat-rejection system. In the winter, it should be capable of providing heating-duct air at a standard temperature (43 °C) when the outdoor ambient air is at the freezing point, or heating-duct air at lower temperatures (e.g., 30 °C) when the outdoor ambient air is much colder (e.g., -15 °C). To date, the system has been tested at the bench scale, and its performance characteristics have been studied in detail. Construction of an intermediate-scale prototype with a 25,000-kcal storage capacity is scheduled for completion by the end of June 1979. Following a one-year in-house test of this unit, EIC is planning to construct a larger-scale prototype suitable for field testing in an instrumented solar home.

B4. PASSIVE THERMAL SYSTEMS

615/81 PASSIVE COOLING SYSTEMS IN HOT ARID REGIONS. M.N. Bahadori (University of Shiraz, Shiraz (Iran)). P. 461-79 of Solar Energy Conversion: An Introductory Course. A.E. Dixon and J.D. Leslie (eds.), Pergamon Press, New York. NY, USA (1979).

The principle of operation of wind towers and curved roofs employed for natural circulation of air through buildings are described. The wind towers can provide both sensible and evaporative cooling of the air whereas the wind blowing over the curved roofs provides an entrainment and sensible cooling of the ambient air through the building. The natural production of ice on clear winter nights and the storage of cold water in deep cisterns are further explained. The natural ice making depends on thermal-radiation losses to the clear sky. The water in cisterns is kept cool all through the summer months by maintaining an evaporation rate from its surface by the draft produced by several wind towers. 7 refs.

616/81 PASSIVE SOLAR HANDBOOK. P.W.E. Niles and K.L. Haggard (California Energy Commission, Sacramento, CA (USA)). California Energy Commission, Sacramento, CA, USA (1980) 332p.

Definitions and fundamental principles are reviewed and the basic passive-system types are presented. The conceptual, analytical, and detailed phases of building design are investigated sequentially for most passive types and energy-conserving buildings. Additional technical information is included in appendices, including the CALPAS and CALPOND simulation programmes.

617/81 ECONOMICAL VERIFICATION OF A FLUIDIZED BED SOLAR GRAPE DRIER. B. Kilkis (Department of Mechanical Engineering, Middle East Technical University, Ankara (Turkey)). P. 384-92 of Tagungsbericht des Dritten Internationalen Sonnenforums (Proceedings of the Third International Solar Forum, held Hamburg, Fed. Rep. of Germany, 24 June 1980). DGS-Sonnenenergie Verlag, München, Fed. Rep. of Germany (1980).

The open-air sun drying of fruits and crops is a wide-spread practice, however, it presents various hygienic and technical problems. To avoid those problems, different artificial-drying methods have been developed and practiced which generally rely upon solar energy, and utilize packed-bed principles. A simple and effective fluidized-bed solar grape dryer was designed such that the drying rate is twice as fast as for standard dryers. A 50 daN of grape-weight capacity bed operates on a 0.9-kW electric motor and is found to be feasible for small farms.

618/81 TECHNICAL AND ECONOMIC FEASIBILITY OF SOLAR PONDS. Z.I.H. Lin (Argonne National Laboratory, IL (USA)), W.T. Sha and S.L. Soo. P. 425-9 of Proceedings of the Systems Simulation and Economics Analysis Conference (held San Diego, CA, USA, 23 Jan. 1980) SERI/TP-351-431 (1980). NTIS. US$37.50.

Information is presented to show that a 4,050-m^2 salt-gradient solar pond can supply adequate heat to meet the grain-drying and space-heating requirements of a typical 2.02×10^6-m^2 Illinois farm. The specific corn-drying and hog-house heating needs of the 3.64×10^6-m^2 Fillman farm, Mazon, Illinois, USA, are also shown to be amply sustainable by such a pond. Calculations are made to demonstrate that solar ponds are becoming economically competitive with fossil fuels. Their additional advantages, potential future uses and possible socio-economic impacts are also discussed. Large-scale demonstration solar ponds for agricultural applications are recommended.

619/81 SEDE BOQER SHALLOW POND PROJECT. A. Kudish (Energy Conversion Unit, Institute for Desert Research, Ben-Gurion University of the Negev, Beer Sheva (Israel)). Energy, vol. 6, p. 277-92 (1981).

The use of shallow solar ponds (convecting solar ponds) for the conversion of solar energy into low-grade thermal energy has been a subject of intensive investigation in recent years. At the Institute for Desert Research at the Sede Boqer Campus tests have been made on this concept with emphasis placed upon the utilization of locally manufactured components. The daily performance of four small-module shallow solar ponds has been monitored almost continuously between August 1978 and May 1979. The ponds are each 2 x 1.3 m in size. They all have the same black PVC lower film, but differ either in the type of upper transparent film, glazing material or glazing angle. The daily performance is characterized by three factors, viz. the maximum daily water temperature achieved, the total daily thermal energy collected and the daily efficiency. Monthly average performance factors for the SSP modules have been determined. Based upon the experimental data, it is concluded that the SSP system is capable of supplying ~ 3 GJ/m^2-y of thermal energy under climatic conditions similar to those prevailing at Sede Boqer, i.e. semi-arid zones. The economic feasibility of such a system has been analysed in comparison with the following alternate energy sources: oil (heavy fraction), natural gas and electricity.

620/81 STUDY ON SOLAR BRAZING. Hamasaki M. and Sumitomo T. (Governmental Industrial Research Institute, Shikoku; Takamatsu, Kagawa (Japan)). P. 250-1 of Proceedings (Kōen Gaiyō) of the Preparatory Meeting of the Japan Welding Society (Yōsetsu Gakkai Zenkoku Taikai). (1979).

Fundamental experiments on solar brazing were conducted using an Al alloy paraboloidal reflector which was fabricated by fixing trapezoidal acryl mirrors on a paraboloid usually used in the radio-frequency region. Several materials (soft steel, stainless steel, copper, brass) were brazed by a preplaced brazing-method, and at that time, silver solder, brass solder, and phosphor bronze solder were tested as hard solders. Good solar brazing was obtained in all cases.

C. BIOCONVERSION ENERGY

621/81 A METHODOLOGY FOR ASSESSMENT OF BIOFUEL RESOURCES IN DEVELOPING COUNTRIES. J.P. Horper and A.A. Antonopolous (Argonne National Laboratory, Argonne, IL (USA)). American Institute of Chemical Engineers Symposium Series, vol. 76, no. 198, p. 151-5 (1980).

A methodology for evaluating the biomass energy that can be usefully employed is presented as the result of a co-operative study undertaken by Peru and USA. 4 refs.

622/81 METHANE OR METHANOL VIA CATALYTIC GASIFICATION OF BIOMASS. D.H. Mitchell, L.K. Mudge, R.J. Robertus, S.L. Weber and L.J. Sealock, Jr. (Battelle Pacific Northwest Laboratories, Richland, WA (USA)). Paper presented at the 89th Annual Meeting of the American Institute of Chemical Engineers (held Portland, OR, USA, 17 Aug. 1980). PNL-SA-8049 (Mar. 1980) 17p. NTIS. US$7.50.

Methane and methanol synthesis gas can be produced by the steam gasification of biomass in the presence of appropriate catalysts. A 5-cm diameter reactor has been used to determine the best catalysts and operating temperature. A process development unit (PDU) has demonstrated the feasibility of the steam gasification of biomass with catalysts at rates up to 35 kg per hour. Methane yields of 0.28 nm^3 per kg of dry wood were produced in a small laboratory reactor. Further methanation of the product gas mixture can increase methane yields to 0.33 nm^3/kg. The catalyst system uses nickel and silica-alumina. The preferred reactor operating temperature is 500 to 550 °C. Tests have been at atmospheric pressure. The PDU performance has confirmed results obtained in the laboratory. Methanol synthesis gas can be produced in a single-stage reactor at 750 to 850 °C by steam gasification of wood with silica-alumina and nickel catalysts present. From this gas, up to 0.6 kg of methanol can be produced per kg of wood. Gasification of the wood to produce synthesis gas has been demonstrated in the laboratory-scale reactor, but remains to be successfully done using the PDU. Catalyst deactivation rates and regeneration schemes must be determined in order to determine the economic feasibility of wood-to-methane or wood-to-methanol processes. Some advantages of catalytic steam gasification of biomass over steam-oxygen gasification are: no oxygen is required for methane or methanol synthesis gas, therefore, no oxygen plant is needed; little or no tar is produced resulting in simpler gas cleaning equipment; no shift reactor is required for methanol synthesis; methanation requirements are low resulting in high conversion efficiency; and yields and efficiencies are greater than obtained by conventional gasification.

C1. BIOMASS PRODUCTION AND CONVERSION

623/81 ARID LAND PLANTS: PROMISING NEW TOOLS FOR ECONOMIC DEVELOPMENT AND BASIC RESEARCH. P. Felker (Department of Soil and Environmental Sciences, University of California, Riverside, CA (USA)). Paper presented at the Symposium on the Economic Development of Desert Plants (held Tucson, AZ, USA, 4 Aug. 1980). CONF-800840-1 (1980) 23p. NTIS. US$7.50.

An overview is presented of arid-land plant development stressing products and plant physiological and ecological concepts unique to arid-land plants. Integration of new arid-land crops into polyculture-management systems is suggested utilizing specialized plant functions, e.g., drought resistance, resistance to salinity, ability to fix nitrogen, frost tolerance and capability to produce a cash crop. Impacts of arid-land plant productivity on political systems of developing countries are discussed and recommendations are presented for overcoming institutional constraints facing arid-land plant development.

624/81 UTILIZATION OF WASTE COCONUT COIR DUST AS A SOURCE OF FUEL. T.F. Festin and W.I. Jose (College of Engineering, University of the Philippines, Diliman, Quezon City (Philippines)). Conversion and Recycling, vol. 3, p. 383-8 (1979).

This article describes the production of gaseous fuel by the pyrolysis of waste coconut-coir dust. 13 refs.

625/81 ALCOHOLIC FERMENTATION OF RAW STARCH WITHOUT COOKING BY USING BLACK-KOJI AMYLASE. Ueda S. and Koba Y. (Kyūshū University, Fukuoka (Japan)). Journal of Fermentation Technology, vol. 58, no. 3, p. 237-42 (June 1980).

The conventional alcoholic-fermentation method requires a large amount of heat for cooking starch prior to its saccharification. The aim of this study is to assess the advantages of alcoholic fermentation from raw starch (such as corn and cassava) without precooking compared to vacuum distillation of ethanol from the broth. In the case of raw-corn starch, about 7%/total volume of broth (v/tv) ethanol was produced from 30% (v/tv) of corn starch every day during 3 days of fermentation with 112 units per ml of broth of amylase of black-aspergillus (Glucuzyme GNL-2000), and this was further increased to about 11% (v/tv) when the fermentation vessel was agitated with a rotary shaker. Furthermore, removing inhibiting substances from the broth increased the producibility of ethanol and about 10% (v/tv) ethanol could be produced every day during 20 days, though the production of ethanol usually decreased after the 4th day.

626/81 DENDRO-THERMAL POWER PLANTS VS. OIL-FIRED POWER PLANTS UNDER PHILIPPINE CONDITIONS. P.V. Bawagan and J.A. Semana (Forest Products Research and Industries Development Commission, Manila (Philippines)). NSDB Technology Journal, vol. V, no. 4, p. 17-24 (1980).

The establishment of dendro-thermal steam-powered plants, fueled by wood from a plantation of giant ipil-ipil, (Leucaena leucocephala (Lam.)) de Wit, and other fast-growing wood species, could assist the Philippines greatly in alleviating the problems brought about by the ever-escalating cost of imported crude oil and the denudation of forest areas. At crude oil cost of US$18 per barrel, the production cost of a 75-MW oil-fired steam-power plant would be US$0.038 per net kWh compared with US$0.026 - US$0.074 per net kWh for dendro-thermal steam-powered plants of 10 to 75-MW capacities. However, at US$37 per barrel of oil, even the 10-MW wood-fired plant will be competitive with the 75 MW oil-fired plant. The dendro-thermal power-plant-fuelwood plantation combination is more advantageous than the oil-fired power plant in terms of employment generation and foreign-exchange conservation.

C2. BIOGAS PRODUCTION AND UTILIZATION

627/81 BIOGAS IN BOTSWANA. B. MacGarry (Rural Industries Innovation Center, Kanye (Botswana)). Biogas Newsletter Nepal, no. 12, p. 4-5 (1981).

The experience gained in small-scale experiments with a 600-l horizontal plug-flow digester, made from three 200-l drums, was used to investigate the possibility of using biogas as a diesel-fuel substitute for powering pump engines at boreholes used for cattle in the arid areas of Botswana. A 10-m^3 Chinese-type digester was used in these tests. The terms of reference of the test and details of the operational plan are included. The use of biogas toilets as efficient low-cost sanitation devices are also being promoted.

628/81 THE ROLE OF CATTLE IN BIOCONVERSION OF SOLAR ENERGY TO BIOGAS AND FOODSTUFFS (PAPEL DEL GANADO VACUNO EN LA BIOCONVERSION DE LA ENERGIA SOLAR EN BIOGAS Y ALIMENTOS). F. deb Hovell and R. Silvestre (Centro de Investigacione Pecuarias con Caña de Azúcar, Consejo Estatal del Azucar, Santo Domingo (Dominican Republic)). P. 261-9 of Caribbean Consultation on Energy and Agriculture (Consulta del Caribe Sobre Energía y Agricultura). Instituto Superior de Agricultura, Santiago, Chile (1980). In Spanish.

The use of biogas as a source of energy in the rural areas is one solution to the needs of communities in developing countries. Its advantages lie in the fact that it can be produced from local raw materials in sitio, and that the technology for its production and use is relatively simple and currently available. At CEAGANA is located a digestor with a capacity of 100 tonnes of dung, and a storage capacity of 90 m^3 of gas. The dung is produced by cattle housed in pens, and fed on a variety of forage (sugar cane, banana, cassava and sweet potato) and molasses. The dung passes by gravity feed to the digestor. This is a large circular concrete tank buried in the ground and capped by a floating metal gas holder. The partially digested dung is then used to fertilize the fields. The cattle receive urea and dicalcic phosphate as supplements and thus effectively inject both nitrogen and phosphorus into the system. The cattle unit is an experimental one and, for experimental reasons, is limited to 96 animals. Typical food intakes by the cattle are about 3.5 kg DM/d. Given a digestibility of 60% by the cattle, this would produce 134 kg DM of manure. The measured gas production over a 3-month period varied from 6.5 to 10.5, averaging 8.1 m^3/DM (corrected to 0 °C and 760 mm Hg). This is a gas production (60% methane) of 0.060 m^2 biogas/kg DM fed into the digester (assuming no loss from beneath the slats). Large amounts of water are used to clean the pens and, therefore, the DM content of the digester is low (about 2-3%) and the retention times short (2-6 days). The gas tank is made from mild steel and suffered considerable corrosion in three years. Since it costs over DR 2,000 pesos, it seems probable that this is not a suitable material in a developing country. Very good forage fields after fertilization by the dung have been obtained. Sweet potato yields of equivalent to 260 tonnes/ha - about 30 tonnes DM and 5.5 tonnes crude protein a year. It is concluded that such a system would have very considerable application in the tropics with the biogas being used to supply power, the dung as a fertilizer, and the cattle for meat and milk. 2 refs.

El uso de biogás como fuente de energía a nivel rural es una solución a las necesidades de las comunidades en los países en vías de desarrollo. Las ventajas estriban en el hecho de que puede producirse la materia prima en el lugar mismo y la tecnología para su producción y uso es relativamente simple y fácilmente disponible. Tenemos en CEAGANA (División Ganadera del Consejo Estatal del Azúcar) un digestor con capacidad para 100 toneladas de estiércol que puede almacenar 90 m^3 de biogás. El estiércol es producido por el ganado alojado en jaulas de rejillas y alimentado con diversos forrajes (caña de azúcar, plátano, yuca y batata) y melaza. El estiércol parcialmente digerido se usa luego para abonar los campos. El ganado recibe en su alimentación urea y fosfato dicálcico como suplemento, los cuales inyectan al sistema tanto nitrógeno como fósforo. La unidad ganadera es sólo experimental y por tanto, por razones experimentales el número de animales se ha limitado a 96. El consumo promedio del ganado es de 3,5 kg MS/día. Con una digestibilidad dada de 60% produciría 134 kg de MS como estiércol. La producción de gas medida en un período de 3 meses varió de 6,5 a 10,5, promedio 8,1 m^3/día (corregido a 0° y 760 mm Hg). Es una producción de gas (60% de metano) de 0,060 m^3/kg MS alimenticia en la digesta (asumiendo que no hay pérdida por debajo de las rejillas). Se usan grandes cantidades de agua para limpiar las jaulas y por tanto el contenido de MS de la digesta es bajo (alrededor de 2-3%) y los tiempos de retención cortos (de 2 a 6 días). El tanque de gas es de acero blando y ha sufrido mucha corrosión en 3 años. Debido a que su costo es superior a los RD$2.000 es probable que éste no sea un material conveniente en un país en desarrollo. Hemos obtenido buena producción de forraje de los campos fertilizados con este estiércol. La batata ha dado un rendimiento equivalente a 260 tons/hectárea-cerca de 30 toneladas de materia seca y 5,5 toneladas de proteína cruda por año. 2 réf.

629/81 STUDIES ON THE BIOGAS PRODUCTION FROM SEVERAL ANIMAL FECES. I.K. Kwon and H.U. Kim. Hanguk Ch'uksan Hakhoe Chi, vol. 20, no. 3, p. 233-42 (1978). In Korean.

Various parameters were studied to maximize CH_4 production from pig, chicken, and cow manure. Inoculation of a fresh tank with old-tank sediment did not increase the total volume of CH_4 produced, it increased the CH_4 production rate. Predigestion of manure did not increase the CH_4 production efficiency. The CH_4 production rate decreased when the tank temperature was decreased from 35 to 20 °C. For the winter management of a CH_4 tank, especially during the cold Korean winter, a cheap solar collector is being tested to warm the tank.

630/81 VOLATILE FATTY ACIDS, AN IMPORTANT STATE PARAMETER FOR THE CONTROL OF THE RELIABILITY AND THE PRODUCTIVITIES OF METHANE ANAEROBIC DIGESTIONS. C.M. Asinari Di San Marzano, R. Binot, T. Bol, J.L. Fripiat, J. Hutschemakers, J.L. Melchior, I. Perez, H. Naveau and E.J. Nyns (Unit of Bioengineering, University of Louvain, Place Croix du Sud, 1 Bte 9, B-1348 Louvain-la-Neuve (Belgium)). Biomass, vol. 1, p. 47-59 (1981).

The importance of the presence of volatile fatty acids, acetate, propionate or higher homologues (either in methanogenic substrates or in digestion mixed liquors) was examined with regard to the reliability of the digestion process and/or the methane productivities through a number of appropriate experiments. From these and other observations, guidelines for the prevention of the occurrence or the removal of these volatile fatty acids in digestion-mixed liquors, whenever harmful, are proposed. 6 refs.

631/81 BALANCED CONCENTRATES OF ORGANIC WASTES ENRICHED WITH SELECTED MICROORGANISMS CULTURES FOR OBTAINING FUEL GAS BASED ON METHANE. R. Ramos de Farias. Brazilian Patent 77-01,551 (19 Sept. 1978). File date: 10 Mar. 1977. 6p. In Portuguese.

Concentrations are prepared from urban wastes such as refuse, straw, hulls and manure. Some wastes are subjected to aerobic fermentation to obtain a clean and odorless product. They are then mixed to obtain a balanced composition, wetted, admixed with selected microorganisms for the anaerobic CH_4-producing fermentation, and followed by the adjustment of the pH to 7.5 to 8.5. The material is finally compressed and pelletized. The anaerobic fermentation of these pellets is carried out in digesters with the addition of a determined amount of water. Thus, a mixture of 25 kg concentrate and 45 l of water would yield 50 to 70 l of gas per day for 45 days.

D. WIND ENERGY

632/81 A NOVEL VERTICAL AXIS SAIL ROTOR. B. Hurley (Low Energy Systems and College of Technology, Bolton St., Dublin (Ireland)). P. 40-7 of Proceedings of the First British Wind Energy Association Wind Energy Workshop (held April 1979).

The rotor comprises at least two rectangular sailwings mounted vertically at equal distances from the central vertical axis. Each sailwing has a vertical rigid spar which forms the leading edge of the sail. Attached are horizontal spars to the free ends of which the trailing edge of the sail is fixed. These keep the sail under tension. The cloth sails assume an aerofoil shape under wind pressure, behaving like aerofoils with constantly changing angle of attack during rotor rotation. During each revolution the sail switches its concave surface from one side to the other automatically, enabling the rotor to develop positive torque, even at low rpm. It is also self-starting. A five-sailwing rotor is illustrated. 15 refs.

633/81 DIRECTION-INDEPENDENT, CONCENTRATION-AUGMENTED SLOW-RUNNING WIND-ROTOR. S. Sivapan and S. Sivasegaram (Department of Mechanical Engineering, University of Peradeniya, Peradeniya (Sri Lanka)). Wind Engineering, vol. 4, p. 134-41 (1980).

This article describes the result of a wind-tunnel study of a direction-independent, concentration-augmented, slow-running wind-rotor of medium size. Concentration augmentation provided a 6% increase in power. 8 refs.

634/81 RIMMED POLYBLADE WIND TURBINE. P.S. Smith (Wind Electric Systems, Inc., CA (USA)) and O.J.M. Smith. Sunworld, vol. 5, no. 2, p. 40-7 (1981).

Based on a modification of the traditional multi-blade windpump, the rimmed poly-blade wind turbine is a wind-driven generator system built to produce electric power for a utility grid. In this machine, high-performance thin aerofoils are used in a structurally simple and reliable system. Both the turbine wheel and the generator, which is located at the bottom of the wheel, are mounted on a tower that can rotate around a track on the platform. The details of the turbine wheel, the aerofoils, the generator, control circuit and tower are described. The results of an examination of the power factor compensation, performance and efficiency are included. 4 refs.

E. ENERGY STORAGE

635/81 STORING SOLAR ENERGY IN AN UNDERGROUND ROCK BED. L.R. Walton, W.H. Henson, S.G. McNeill and J.M. Bunn. Transactions of the American Society of Agricultural Engineers, vol. 22, no. 5, p. 1202-7 (1979).

The maximum temperatures reached by an insulated and an uninsulated underground rock bed were 52 °C and 39 °C, respectively. The insulated rock bed reached a quasi-steady-state condition in which each additional day of charging approximately equaled the heat losses occurring over a 24-hour period. The temperature profile, after reaching steady state, exhibited a harmonic response to the collector outlet temperature at steady state and the thermal decay of the rock bed.

636/81 LATERAL FLOW CONCEPT FOR ROCK BED SYSTEMS. J.C. Christopher (Contemporary Systems, Inc., Walpole, NH (USA)). Solar Engineering Magazine, vol. 4, no. 8, p. 15-7 (Aug. 1979).

The thermal-storage and heat-flow characteristics of a lateral-flow rock-bed system are described. In the lateral-flow storage system, the air moves horizontally through the rock bed, thus avoiding vertical stratification with resulting premature thermal breakthrough and allowing longer path lengths. Various design concepts for rock-bed storage systems are considered, including volumetric air flow and its introduction into the rock medium. The results of an experiment to determine the breakthrough time and pressure-loss characteristics of a packed-stone bed are presented. The importance of adequate insulation is discussed.

637/81 SOLAR ENERGY AND LOW LEVEL CYCLIC ENERGY FLOW (20 TO 100 °C) STORAGE AS CHEMICAL BOND ENERGY OF COMPOUNDS UNDERGOING THERMAL DECOMPOSITION. FINAL REPORT. J. Bougard, P. Capron and R. Jadot (Centre de Recherches sur l'Energie Solaire, Faculté Polytechnique de Mons, Mons (Belgium)). (1980) 238p.

Various materials and reactions were studied for the thermo-chemical storage of heat at low temperatures. Thermo-chemical reactions with water vapour were studied including selected hydrates and some adsorbents and molecular sieves. Silica gels were studied in detail including physical properties and the basic principles of the reversible adsorption phenomenon. Thermo-chemical heat storage based on reactions with ammonia are considered, and the discontinuous heat pump is discussed.

638/81 THERMAL ENERGY STORAGE USING HEAT OF SOLUTION. P. Kulisic, J. Vuletin, J. Mastelic, M. Bosanac and B. Prib (Elektrotehnicki Fakultet, University of Zagreb, Zagreb (Yugoslavia)). P. 666-73 of Tagungsbericht des Dritten Internationalen Sonnenforums (Proceedings of the Third International Solar Forum (held Hamburg, Fed. Rep. of Germany, 24 June 1980). DGS-Sonnenenergie Verlag, München, Fed. Rep. of Germany (1980).

The fact that some salts dissolve endothermically with a positive coefficient of solubility can be used as a means for storing thermal energy. In this work, thermal energy storage using saturated aqueous solutions of KNO_3, $NaNO_3$, NH_4NO_3 and NH_2CONH_2 was experimentally investigated and specific-heat capacities were determined and compared with calculated values. Heats of solution for saturated solutions were also estimated and were found to be smaller than those for a high degree of dilution. Particularly the saturated solution of KNO_3 looks promising and a mixture of 46% KNO_3 and 54% H_2O is suggested for a thermal-energy storage material.

F. SOCIO-ECONOMIC ASPECTS

639/81 ENVIRONMENTAL EFFECTS OF HARVESTING FORESTS FOR ENERGY. R.I. Van Hook, D.W. Johnson, D.W. West and L.K. Mann (Oak Ridge National Laboratory, Oak Ridge, TN (USA)). Paper presented at the Bio-energy World Congress and Exposition (held Atlanta, GA, USA, 21-24 Apr. 1980). CONF-800482-2 (1980) 17p. NTIS. US$7.50.

Present interest in decreasing US dependence on foreign oil by increasing the use of wood for energy may bring about a change in US forest utilization policies. In the past, forests have been removed in areas believed to be suited for agriculture. Sometimes, sawtimber and pulp have been the only woody material removed in any quantity from land not generally considered tillable. The new demands on wood for energy are effecting a trend toward (1) removing all woody biomass from harvested areas, (2) increasing the frequency of harvesting second-growth forests, and (3) increasing production with biomass plantations. Considering the marginal quality of much of the remaining forested land, the impacts of these modes of production could be significant. For example, it is anticipated that increased losses of nutrients and carbon will occur by direct forest removal and through erosion losses accelerated by forest clearing. There are, however, control measures that can be utilized in minimizing both direct and indirect effects of forest harvesting while maximizing woody biomass production.

640/81 ECONOMIC ANALYSIS OF ETHANOL PRODUCTION BY FERMENTATION. Yoshino A. and Nitta Y. (Central Research Institute of Electric Power Industry, Ltd. (Japan)). Report of the Central Research Institute of Electric Power Industry (Denryoku Chūo Kenkyūjo Enerugī Kankyō Gijutsu Kenkyūjo Hōkoku), p. 1-24 (1980). In Japanese.

This paper gives an economic analysis of ethanol-production processes by fermentation. For 1-km^2 plantations to grow either sugar-cane or cassava, facilities and machines cost 46.9 million yen (Japanese). Equipment, labour and repayment require 23.4 million yen. To obtain 1 liter of alcohol, the cultivation of sugar-cane and cassava requires 82 yen and 62 yen respectively. Five billion yen is needed to install a 150 kl/day alcohol-fermentation factory (3 yen per liter of alcohol). The ultimate alcohol cost (including a 30% margin) is 142 yen/l and 122 yen/l from sugar-cane and cassava, respectively. To produce 1 liter of alcohol which has 6,000 kcal, either 4,000 kcal or 9,700 kcal is required from sugar or starch, respectively in the fermentation process. 25 refs.

641/81 THE COST-EFFECTIVENESS OF WATER-PUMPING WINDMILLS. P.R. Gingold. Wind Engineering, vol. 3, p. 231-62 (1979).

The cost of pumping water using a diesel unit is compared with the cost of a windmill for various sites throughout the Third World. The method of calculation is presented for the various types of systems considered. 27 refs.

642/81 SOCIAL AND ECONOMICAL ASPECTS OF THE INTRODUCTION OF GASIFICATION TECHNOLOGY IN THE RURAL AREAS IN THE DEVELOPING COUNTRIES, E.G. TANZANIA. M.J. Groeneveld and K.R. Westerterp (Department of Chemical Engineering, Twente University of Technology, Enschede 7500 (Netherlands)). Chemical Age of India, vol. 31, no. 3, p. 185-93 (1980).

The feasibility of gasifying maize cobs in Tanzania is studied. 9 refs.

643/81 SOCIAL STRUCTURE AND RURAL ENERGY TECHNOLOGY. P. Hayes (Energy and Resources Group, University of California, Berkeley, CA 94720 (USA)). P. 37-47 of Southern Prospectives on the Rural Energy Crisis. Nautilus, Inc., Box 535, Bolinas, CA 94924, USA (August 1981).

Detailed reports of rural energy in Bangladesh, Zambia and Nepal are examined and, on the basis of these and other examples, alternative theories for the adoption of new rural energy technologies are reviewed. The frameworks for analysing these theories are classified as conventional wisdom and non-conventional wisdom. While this paper deals with the linkage between the micro-phenomena and macro-structures, it is stressed that it should not be concluded that the only means of achieving technological changes is for a global realignment of social relationships of production. Two short-term strategies are potentially feasible. The first approach recognizes the distribution of consequences of technological changes but argues that these are necessary human costs for a longer-term goal. Such a goal can be humane or simply a technocratic commitment to the deployment of a new technology regardless of the social costs. The second argues that technological development should be pursued if it contributes to the satisfaction of basic human needs beginning with the needs of the neediest, endogenous self-reliance through social participation and control, and harmony with the environment.

MEMBERS OF THE ASSET NETWORK

The list below includes the names and addresses of the members of the ASSET information network who joined in 1981. However, only those scientists and engineers working in developing countries whose yellow ASSET Request Form have been received at United Nations University headquarters are included in the list. Anyone who has returned an ASSET Request Form but whose name is not included in the list or whose name or address is included incorrectly is kindly requested to contact the ASSET office so that errors and oversights can be corrected. In many cases, the information provided on the ASSET Request Forms was not sufficiently detailed to permit inclusion of the fields of activity of members of the ASSET network in the list. All names in the list are arranged alphabetically by surname under the country of residence. An attempt has been made to respect to the best of our knowledge the various cultural practices with regard to that part of personal names which serve the function of a surname or formal name.

ANGOLA

Munzila Jackson Donão	Ministry of Energy, C.P. 10704, Luanda.

ARGENTINA

Roland H. Braun Wilke	IADIZA, Casilla de Correo 507, 5500 Mendoza.
John Martin Evans	Rosetti 1540 2°A, 1602 Florida, Provincia de Buenos Aires.
Mario A. Farias	Servicio Centralizado de Documentación, Casilla de Correo 131, 5500 Mendoza.
Rubén H. Vallejos	Centro de Estudios Fotosintéticos y Bioquímicos, Suipacha 531, 2000 Rosario.

BOLIVIA

Edwin C. Copeland	Misión Bautista Canadiense, Casilla 86, Santa Cruz.
Hugo Loaiza Terán	Centro Nacional de Documentación Científica y Tecnológica, Casilla 3283, La Paz.

BOTSWANA

James Mpotokwane	Ministry of Agriculture, Private Bag 003, Gaborone.
Annette Tuebner	The Botswana Technology Centre, P.O. Box 438, Gaborone.

BRAZIL

Paulo I.F. de Almeida	Laboratório de Energia Solar, Universidade Federal da Paraíba, Campus Universitário, 58000 João Pessoa, Pb.
Lutero Carmo de Lima	Universidade Federal do Mato Grosso, Depto. Física, 78.000, Cuiaba, MT.
R. Ladchumananandasivam	Universidade Federal do Rio Grande do Norte, Centro de Tecnologia, Departamento de Engenharia Mecânica, Natal, RN.
Shiva Prasad	Dept. de Engenharia Quimica, Centro de Ciências e Tecnologia, Universidade Federal da Paraíba, 58.100, Campina Grande, Paraíba.
Victor Henrique Russomano	Instituto Desenvolvimento Econômico Gerencial - IDEGTEC, Avenida Calógeras 15, 20.030 Rio de Janeiro.
Debi Pada Sadhu	Universidade Federal do Rio Grande do Sul, Rua Sarmento Leite, 425, Porto Alegre, 90.000, RS.

CAMEROON

Timma	Laboratoire de Recherches Energétiques - Yaoundé, Institut de Recherches Géologiques et Minières, BP 5110, Yaoundé.

CHILE

Ingo Junge Rodewald	Consultores Regionales Asociados, O'Higgins 192, Casilla 116-C, Concepción.
Aldo Moisan	Dpto. Ing. Mecánica, Sec. Termofluidos, Facultad de Ingeniería, Universidad de Concepción, Casilla 53-C, Concepción.

CHINA

Cai Yi-Han	Energy Resources Laboratory, University of Tianjin, Tianjin.
David H.C. Hoh	Ministry of Agricultural Machinery, Guangdong Institute of Agricultural Machinery, Sipai, Guangzhou.
Huang Guo-zhi	"Biogas" Editorial Board, Chungqing Branch, China Institute of S&T Information, Chungqing, Sichuan Province.
Hu Chengchun	Second Bureau, The State Scientific and Technological Commission of the People's Republic of China, Beijing.
Lin Hanxiong	The State Scientific and Technological Commission of the People's Republic of China, Beijing.
Wang Tai Quan	Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, 81 Central Martyrs' Road, Guangzhou.

COLOMBIA

Bernardo Ospina Patiño	Centro Internacional de Agricultura Tropical, Apartado Aéreo #67-13, Cali.

COSTA RICA

Juan Mamel Villasuso E.	Instituto de Investigaciones en Ciencias Económicas, Universidad de Costa Rica, Ciudad Universitaria "Rodrigo Facio", San José.

CUBA

Oraldo Morales Ceballos	Comité Estatal de Colaboración Económica, Calle 1ra. No. 201 esq. B, Vedado, La Habana.

CYPRUS

David Robert Morris	D.M. Natural Energy Systems, Ltd., Box 1830, Limassol.

DOMINICAN REPUBLIC

José Ramón Acosta	Comisión Nacional de Política Energética, Edif. Plaza Compostela, 5° piso, Avenida John F. Kennedy, P.O. Box 304-2, Santo Domingo.
Norberto A. Quezada	Instituto Superior de Agricultura, Apartado Postal 166, Santiago.

EGYPT

M.S.E. Abdo	Dept. of Chemical Engineering, Faculty of Engineering, Alexandria University, Alexandria.
Serag El-Din Habib	Dept. of Electronics, Faculty of Engineering, Cairo University, Cairo.
Mohamed M. Hafiz	Dept. of Physics, Faculty of Science, Assiut University, Assiut.
Ahmed I. Khodair	Faculty of Science, Suez Canal University, Ismailia.
Hani Fikri Ragaie	Dept. of Electronics & Computer, Faculty of Engineering, Ain Shams University, Cairo.
M.A.B. El-Koshairy	Renewable Energy Supreme Council, Ministry of Electricity and Energy, Abbassia, Cairo.

EL SALVADOR

Víctor Orlando Valle Villalta	Comisión Ejecutiva Hidroeléctrica del Río Lempa (CEL), 9a. Calle Poniente #950, Centro de Gobierno, San Salvador.

ETHIOPIA

Tesfaye Dama	Faculty of Technology, Addis Ababa University, P.O. Box 385, Addis Ababa.
Wudnesh Hailu	Awassa Junior College of Agriculture, Addis Ababa University, P.O. Box 5, Awassa, Sidamo.

GABON

Posso Paul	Département de Biologie, Faculté des Sciences, l'Institut de Recherche en Ecologie, B.P. 911, Libreville.

GHANA

Victor C.K. Kakane	Dept. of Physics, University of Ghana, Legon.
Keenas Kwest Ortsin	Dodowa Co-operative Multi-Purpose Society Ltd., (Farmers Producers Co-op), P.O. Box 73, Dodowa, Greater Accra.

GUYANA

Bernard Crawford	The National Energy Unit, 295 Murray Street, Georgetown.

INDIA

Prakash Chandra Agrawal	Dept. of Mechanical Engineering, M.B.M. Engineering College, Jodhpur 5, Rajasthan.
J.R.B. Alfred	Dept. of Zoology, School of Life Sciences, North-Eastern Hill University, Nongthymmai, Shillong 793003.
B. Bandyopadhyay	Centre of Energy Studies, Indian Institute of Technology, Hauz Khas, New Delhi 110016.
V.C. Bhavsar	Corporate R&D Division, Bharat Heavy Electricals, Ltd., Vikas Nagar, Hyderabad 500593.
S.C. Chowdhary	Wind Power Utilization Section, Central Arid Zone Research Institute, Jodhpur 342003, Rajasthan.
M.S.M. Christopher	School of Biological Sciences, Madurai Kamaraj University, Madurai 625021.
Aman Dang	Centre of Energy Studies, Indian Institute of Technology, Hauz Khas, New Delhi 110016.
M.V. Desai	Editors' Guild of India, A2 Gulmohar Park, New Delhi 110049.
Prabhakar B. Ghate	67 Vasant Marg, Vasant Vihar, New Delhi 110057.
Debasish Ghosh	Worldlink Development Corp., P.O. & Vill, BEWA Distt., Murshidabad, Farakka Barrage 742212, West Bengal.
F.P. Gillet	Centre for Appropriate Technology, Thirumalai - Chunkankadai, P.O. Pin 629807, Kanyakumari District, Tamil Nadu.
V. Gopinathan	Central Metal Forming Institute, HMT Limited Township P.O., Hyderabad 500854.
A.V. Gunasekhar	Rm. 340, PGP Hostel, NITIE, Vihar Lake, Bombay 400087.
S.R. Hiremath	India Development Service (International), 98/2/Kelgeri Road, Dharwad 580008, Karnataka.
B.C. Jain	Jyoti Limited, P.O. Chemical Industries, Baroda 390003.
K.S. Jayaraman	Press Trust of India, 4 Parliament Street, New Delhi 110001.
Anjan Kalia	Dept. of Soil Sciences & Water Management, Himachal Pradesh Agricultural University, Palampur 176062, Himachal Pradesh.
Thakral Surendra Kumar	IV Division, U.P. Jal Nigam (State Water & Sewerage Corporation), 4A-La Place, Lucknow 226001, Utter Pradesh.
Anil K. Lala	Dept. of Chemistry, Indian Institute of Technology, P.O. IIT Powai, Bombay 400076.
B.S. Magal	Dept. of Mechanical Engineering, Indian Institute of Technology, Powai, Bombay 400076.
Prasanna Mohanty	School of Sciences, Jawaharlal Nehru University, New Delhi 110067.
K.A. Nagarajan	45, Erode Road, Kavindapadi 638455, Tamil Nadu.
Ashis Nandy	Centre for the Study of Developing Societies, 29 Rajpur Road, Delhi 110054.

P. Navaneethakrishnan	Institute for Environmental Sciences, Madurai Kamaraj University, Palkalainagar, Madurai 625021.
S. Neelakantan	Dept. of Food Technology, Tamil Nadu Agricultural University, Coimbatore 641003.
A.C. Pandya	Gujarat Energy Development Agency, 3rd Floor, B.N. Chambers, R.C. Dutt Road, Baroda 390005.
Prabhat M. Poddar	Sri Aurobindo Society Research, Sri Aurobindo Society, Pondicherry 605002.
Jai Prakash	Dept. of Physics, Ramjas College, University of Delhi, B-3/4, Model Town, Delhi 110009.
R.V. Raghavan	Colour Publications Private Ltd., 126.A Dhuruwadi off Dr. Nariman Road, Bombay 400025.
K.S.N. Raju	Dept. of Chemical Engineering and Technology, Panjab University, Chandigarh 160014.
B. Ramachandra Rao	University Grants Commission, Bahadur Shah Zafar Marg, New Delhi 110002.
T.S.S. Rao	National Institute of Oceanography, Biological Oceanography Div., Dona Paula 403004, Goa.
N.M. Reddy	Dept. of Aeronautics, Indian Institute of Science, Bangalore 560012.
Gyan Sagar	VI Circle, U.P. Jal Nigam, C-279, Nirala Nagar, Lucknow 226007.
Birendra Singh Semwal	Dept. of Physics, Garhwal University, Srinagar 246174, Garhwal, Uttar Pradesh.
Ashok Kumar Sharma	Solar Energy Lab. (1), Centre of Energy Studies, Indian Institute of Technology, Hauz Khas, New Delhi 110016.
Suresh Kumar Sinha	Indian Agricultural Research Institute, Water Technology Centre, New Delhi 110012.
V.K. Srivastava	Dept. of Physics, University of Roorkee, Roorkee 247672.
Ram Swarup	Dept. of Physics, D.S. College, Aligarh 202001, Uttar Pradesh.
M.S. Swaminathan	Planning Commission, Yojana Bhavan, New Delhi 110001.
K.P. Vasudevan	The B.B.T.C. Ltd., Mukottu Mudi Factory, Mudis P.O. 642117, Coimbatore District, Tamil Nadu.
V. Venugopal	Listeners Association, 15-M/5, Palanisamy Gounder St., Kavandapadi 638455.

INDONESIA

Tengku Ibrahim	Jalan Panorama 39, Setiabudi, Bandung.
Adjat Sudradjat	Volcanological Survey of Indonesia, Diponegoro 57, Bandung.

IRAN

Wahidi Ramazan	Solar Energy Group, Atomic Energy Organization of Iran, P.O. Box 314-1673, Tehran.

IRAQ

Mohammed Zeki Mohammed	Building Materials Enterprise, Khalid bin Alwaleed St., Mosul.

IVORY COAST

Mohamed Charles	Dept. de Physique, Faculté des Sciences, Université Nationale de Côte d'Ivoire, 04B322 Abidjan 04.

JAMAICA

Alfred M. Sangster	c/o C.A.S.T., 237 Old Hope Road, Kingston 6.

KENYA

M.B. Dar	Africa Book Services (EA) Ltd., P.O. Box 45245, Nairobi.
Godwin E. Kayondo	Dept. of Electrical Engineering, University of Nairobi, P.O. Box 30197, Nairobi.
Ojeri K.S. Sapoke	Chepnyalilo, Cheptvech, Olenguruone, Molo.
K.M. Siddiqui	Dept. of Mechanical Engineering, University Nairobi, Box 30197, Nairobi.
Narayan Shriram Walkade	Dept. of Electrical Engineering, University of Nairobi, P.O. Box 30197, Nairobi.

KOREA

Hee Yong Lee	Dept. of Physics, College of Natural Science, Kangwon University, Hyoja-Dong, Chunchon, Kangwon 200.

LEBANON

Aftim Acra	Dept. of Environmental Health, Faculty of Health Sciences, American University of Beirut, Beirut.

LIBYA

Saleh M. Abughres	Centre for Solar Energy Studies, A.D.I., Tripoli P.O. Box 8004, S.P.L.A.J.

MALAYSIA

Low Theng Heng	Ranhill Bersekutu, 6.01 Tingkat 6, Wisma Central, Jalan Ampang, Kuala Lumpur.
Rudy Ingwer Hutagallung	Dept. of Animal Sciences, University of Agriculture Malaysia, Serdang, Selangor.

Rahim Salam	Dept. of Physics, University of Malaya, Kuala Lumpur.
Noordin Sopiee	The New Straits Times, 31 Jalan Riong, Kuala Lumpur.

MALI

Drame Abdoulaye	Ecole Nationale d'Ingénieurs, B.P. 242, Bamako.

MALTA

Charles J. Falzon	Faculty of Management Studies, University of Malta, Msida.

MAURITIUS

Kassiap Deepchand	Sugar Technology Division, School of Industrial Technology, University of Mauritius, Reduit.

MEXICO

Edmundo Arias T.	Instituto Mexicano de Tecnologías Apropiadas - IMETA, vía Gustavo Baz 1015 Casa 7, Tlalnepantla, Edo. de México.
Gustavo Best	Comisión Económica para América Latina, Presidente Mazaryk 29, Polanco, México, D.F.
Alejandro Fernández	Dirección General de Aprovechamiento de Aguas Salinas y Energía Solar, Boulevard Pipila No. 1, Tecamachalco, México 10, D.F.
Eduardo Ramos	Instituto de Investigaciones en Materiales, Ap. Postal 70-360, México 21, D.F.
Rafael A. Salgado	Instituto de Ingeniería, Universidad Nacional Autónoma de México, Ciudad Universitaria, México 20, D.F.
John Telford	Area de Ciencias Químicas, Universidad Autónoma de Chiapas, Apartado Postal 594, Tapachula, Chiapas.

MOZAMBIQUE

Rute Serrano	CEDIMO - Centro Nacional de Documentação e Informação de Mozambique, Caixa Postal 4116, Rua de Rádio Mozambique, Maputo, R.P.

NIGERIA

O. Afolabi	Dept. of Chemistry, University of Ife, Ile-Ife.
O.A. Bamiro	Dept. of Mechanical Engineering, Faculty of Technology, University of Ibadan, Ibadan.
M.A.C. Chendo	Dept. of Physics, University of Lagos, Lagos.
Clement O. Folayan	Dept. of Mechanical Engineering, Ahmadu Bello University, Zaria, A.B.U.
O. Odeyemi	Dept. of Microbiology, University of Ife, Ile-Ife.
A.M. Salau	Dept. of Physics, University of Ife, Ile-Ife.
E.F. Schmitter	Dept. of Physics, University of Lagos, Akoka, Lagos.

PAKISTAN

M. Altaf Khan	Dept. of Microbiology, Karachi University, C-57 University Staff Town, Karachi-32.
Amir Ahmad Naqwi	Dept. of Mechanical Engineering, NED University of Engineering and Technology, Karachi-32.
Muhammad Saleh Shaikh	Dept. of Electrical Engineering, NED University of Engineering and Technology, Karachi-32.

PANAMA

José Félix Coronado Delgado	Instituto de Recursos Hidráulicos y Electrificación, Dirección de Desarrollo, Apartado 5285, Panamá 5.
Armando Osorio Ríos	Instituto de Recursos Hidráulicos y Electrificación, Dirección de Desarrollo, Apartado 5285, Panamá 5.

PHILIPPINES

Portia A. Nayve	Asian Recycling Association, P.O. Box 753, Bacolod City, Negros Occidental.
Mary Auce O'Rourke	Maryknoll Convent, 74 P. Burgos, Quezon City, Metro Manila.
Elma B. Torres	Institute of Public Health, University of the Philippines System, 625 Pedro Gil St., Ermita, Manila.

PORTUGAL

António João Lopes	Centro de Investigacão e Pesquisa para o Desenvolvimento (CIPD), Av. Miguel Bombarda 91-1, 1000 Lisboa.

QATAR

Brian Nicholls	Gulf Times, Doha, P.O. Box 2888, Doha.

RWANDA

Prospermpawenayo	University of Rwanda, Centre d'Etudes et d'Applications de l'Energie au Rwanda, BP 117, Butare.

SAUDI ARABIA

Mir Ibrahim Ali Asif	College of Agriculture, King Faisal University, P.O. Box 380, Al-Hasa.
Ergun Ar	School of Graduate Studies, University of Riyadh, P.O. Box 1241, Riyadh.
Adil M. Hassib	Dept. of Physics, Faculty of Science, University of Riyadh, Riyadh.

SENEGAL

Cheikh Momar Mbow	Laboratoire des Semi-conducteurs et de l'Energie Solaire, Université de Dakar, Dakar Fann.
Ibrahim Cissé	Direction de l'Innovation et du Progrès Technologique, Secrétariat d'Etat à la Recherche Scientifique et Technique, Dakar.

SIERRA LEONE

Andrew Augustine Baimba	Dept. of Physics, Njala University College, P.M.B. Freetown.

SUDAN

Farouk Idris Habbani	Dept. of Physics, Faculty of Science, University of Khartoum, P.O. Box 321.
Turi Hammer	Integrated Sahel Programme, P.O. Box 302, El Obeid.
Yahia H. Hamid	Faculty of Engineering and Architecture, University of Khartoum, Khartoum.

SYRIA

Mohamad Kordab	Faculty of Mechanical and Electrical Engineering, Damascus University, B.P. 86, Damascus.

TANZANIA

Derek Peter Grace	Carlbro-Cowiconsult-Kampsax-Kruger (C.C.K.K.), P.O. Box 570, Iringa.
Fili Karashani	Progress Magazine, Box 6999, Dar es Salaam.

THAILAND

Marcus M. Sherman	Volunteers in Technical Assistance, 48 Soi Aree 1, Phaholyothin Rd., Bangkok-4.

TURKEY

Ahmet Ecevit	Dept. of Physics, Middle East Technical University, Ankara.
Babyigit Mustafa	Mineral Research Institute of Turkey, M.T.A. Enstitüsü Jeofizik Dairesi, Ankara.
Mete Turan	Faculty of Architecture, Middle East Technical University, Ankara.

UGANDA

Egac Rodney	c/o R.C. Owira Co-op Bank Ltd., P.O. Box 957, Gulu.

UNITED ARAB EMIRATES

A.H.M. Shousha	Dept. of Physics, United Arab Emirates University, Al Ain.

URUGUAY

Carlos M. Serrentino	Dirección Nacional de Meteorología, Casilla de Correo No. 64, Montevideo.

VENEZUELA

Antonio Cavero	Dept. of Termodinámica, Universidad Simón Bolívar, Apartado Postal No. 80659, Caracas.

ZAIRE

Moanda H'deko	Université Nationale du Zaire, B.P. 255, Kinshasa XI.

ZAMBIA

K.K. Gopinathan	Dept. of Physics, University of Zambia, P.O. Box 32379, Lusaka.
Prem Chand Jain	Dept. of Physics, University of Zambia, P.O. Box 32379, Lusaka.

ZIMBABWE

Ronnie M. Chiviya	Ministry of Industry and Energy Development, P.O. Box 8434, Causeway, Salisbury.

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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5

ASSET

3/INDEX

Abstracts of Selected Solar Energy Technology

Index, Volume 3, 1981

太阳能 SOLAR ENERGY СОЛНЕЧНАЯ ЭНЕРГИЯ सौर ऊर्जा ENERGÍA SOLAR সৌর শক্তি
SONNENENERGIE ENERGIA SOLAR الطاقة الشمسية 太陽エネルギー ENERGI MATAHARI
ÉNERGIE SOLAIRE सूर्य शक्ति ENERGIA SOLARE شمسی توانائی DAYANING SURYA 태양에너지
ஞாயிற்றியலான ஆற்றல் సూర్య శక్తి دهوپ دی طاقت GÜNEŞ ENERJİSİ СОНЯЧНА ЕНЕРГІЯ
NĂNG LƯỢNG MẶT TRỜI ENERGIA SŁONECZNA સૂર્ય શક્તિ СОЛАРНА ЕНЕРГИЈА ಸೂರ್ಯ ಶಕ್ತಿ
انرژی خورشیدی സൂര്യോർജ്ജം KARFIN HASKEN RANA ସୂର୍ଯ୍ୟ ଶକ୍ତି NISHATI YA JUA နေစွမ်းအင်
พลังงานแสงอาทิตย์ ENERHIYA NG ARAW ENERGIE SOLARĂ SOLENERGI ZONNE ENERGIE
ਸੂਰਜ ਦੀ ਸ਼ਕਤੀ دلمر انرژی SLUNEČNÍ ENERGIE ÉNESI PANON POÉ قوتِ سورج NAPENERGIA
TENAGA SURIA AGBARA ÕRUN SEMBE DIGA NAANGE IKE ANYANWU ພະລັງ ຈາກ ແສງອາທິດ
AMANDLA ELANGA සූර්ය රශ්මි බලය ҚУЁН ЭНЕРГИЯСИ گئون انرژیسی ΗΛΕΙΑΚΗ ΕΝΕΡΓΕΙΑ
ENERHIYA SA ADLAW سج جي قوتُ የፀሐይ ፡ ኀይል СЛЪНЧЕВА ЕНЕРГИЯ SUNČANA ENERGIJA
ENÈGI SOLÈY ሁምና ፡ አዱ ថាមពល ព្រះអាទិត្យ KOWADDA PANASSA AREH HERIN'NY MASOANDRO
INTI KALLPA UMULIRO W'IZUBA ཉི་མའི་ནུས་པ། ҚУН ЭНЕРГИЯСЫ OWIA AHOƆDEN DAI5YAŋ2 Nəŋ2
AURINKOENERGIA ENERHIA ITI INIT TIYA I NTANGU ENERGI DEL SOLELH SLNEČNA ENERGIA
TABARTA QORAXDA ĶUYAX ENERGIYISI ENERGJI DIELLORE ԱՐԵՎԻ ԷՆԵՐԳԻՅԱ
КҮНӘШ ЕНЕРКИЈАСЫ მზის ენერგია HXO BBU WE ENERHIYA SANG ADLAW NGUYA YA MOYI
TANAGO MATOARI সিং চাঙৌ ডাক ናዮፀሐየ ፡ ኀየሊ PAYU MATAN-AI روچ تاب KILE BARKA
ENERHIA HALI SA ALDAW AWATANGENNA MATANNA ESSOE ODUDU UTIN ŋDO ZAZA
AMAANYI GA ENJUBA אנרגית השמש DONO KAUSU BE آفتابک قوّت هیزی هه تاوی
HINYA WA RIUA SAULĖS ENERGIJA BUKOLE BWA MUNYA UTAÑA UÁTUA TAIYANG NENG
NGUYA EA WANE WĨNTOOG TUULEM MPHAMVU YA DZUWA SIMBA RE ZUWA
MATLA A LETSATSI CUARAJHY MBARETÉ KATAN U JANTE BI

THE UNITED NATIONS UNIVERSITY

The publication and distribution of **Abstracts of Selected Solar Energy Technology (ASSET)** is an activity of the Energy Systems and Policy Sub-programme of the United Nations University. The purpose of **ASSET** is to provide scientists and engineers working in developing countries with abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic impacts of their introduction. Special care is taken to include all available information applicable to rural communities in developing countries.

Correspondence should be addressed to ASSET, The United Nations University, Toho Seimei Building, 15-1 Shibuya 2-chome, Shibuya-ku, Tokyo 150, Japan.

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ASSET gratefully acknowledges the abstracts provided from the computer files and/or documents of the following institutions (in alphabetical order):

Japan Information Center of Science and Technology
2-5-2 Nagata-cho, Chiyoda-ku, Tokyo 100, Japan

Tata Energy Research Institute
Bombay House, 24 Homi Mody Street, Bombay 400 023, India

Technical Information Center (DOE), P.O. Box 62
Oak Ridge, Tennessee 37830, USA

Technology Application Center (NASA), University of New Mexico
Albuquerque, New Mexico 87131, USA

Recipients are encouraged to provide **ASSET** with copies of their publications concerning the technological and socio-economic aspects of solar, bioconversion and wind energy utilization for abstracting in future issues.

THE UNITED NATIONS UNIVERSITY
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INTRODUCTION

The United Nations University has undertaken the establishment of an information dissemination service in the areas of solar, bioconversion and wind energy technology applicable to developing countries. The purpose of this service is to link scientists and engineers active in these fields in developing countries through an information network so that they may benefit from data on the latest advances in technology of importance to their work.

The publication of Abstracts of Selected Solar Energy Technology (ASSET) is the first phase of this service. It contains abstracts of recent books, articles, reports and conference papers concerning solar, bioconversion and wind energy technologies and the socio-economic aspects of their utilization. Care is taken to include all available information applicable to rural communities in developing countries. Each issue also includes one complete reprinted paper of particular interest to recipients. Early issues will contain abstracts of recent publications balanced with those from the extensive older literature which may be of interest to recipients. The abstracts are classified into the following categories:

A. General

B. Solar Energy
  B1 Radiation Measurement
  B2 Photovoltaic Conversion
  B3 Active Thermal Systems
  B4 Passive Thermal Systems

C. Bioconversion Energy
  C1 Biomass Production and Conversion
  C2 Biogas Production and Utilization

D. Wind Energy

E. Energy Storage

F. Socio-Economic Aspects

Solar dryers, ponds, and some architectural and water heating systems form the bulk of the category of Passive Thermal Systems; most other thermal systems are included in the category of Active Thermal Systems.

All abstracts in ASSET are in English. When a non-English language abstract is available in the original language of the document, this will also be included. When sufficient demand warrants it, other language editions, e.g., French and Spanish, will be published.

Scientists and engineers in developing countries who wish to participate in this information network and receive ASSET regularly may do so free of charge. ASSET is available in industrialized nations at an annual subscription rate of US$25 by sea mail and US$40 by air mail payable by cheque, money order, bank draft or UNESCO book coupons to the United Nations University. ASSET has published lists of the names and addresses of all members of the network as of 1 December 1981 in vol. 1, no. 12 (1979), vol. 2, no. 10 (1980) and vol. 3, no. 10 (1981).

Members of the network are requested to send the ASSET office in Tokyo copies of relevant books, articles, reports and conference papers which they write so that the results of their work can be shared with fellow members. These documents will then be abstracted in future issues of ASSET. It is also hoped that members will make recommendations, based on their needs, for improving the contents of ASSET and the services offered through the information network.

Once the first phase of the service has been well established, it is planned to launch the second phase providing for the distribution to members, upon request, of full copies of all documents furnished by network members to the ASSET office in Tokyo. In the third phase, it is expected that the service will furnish upon request full texts of all documents abstracted in ASSET. During the first phase, however, it is recommended that participants, wishing copies of the full documents abstracted in ASSET, contact the authors directly. For this purpose, where available, the first author's institution and location are indicated in the abstract.

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TABLE OF CONTENTS

INTRODUCTION 1
TABLE OF CONTENTS 2
SUBJECT INDEX 2
  Introduction 2
  Outline 3
  Keyword Index 4
  Subject Index 7
AUTHOR INDEX 29
SELECTED ARTICLE LIST 44
SPECIAL CONFERENCE ISSUE - LIST OF ARTICLES 44

SUBJECT INDEX

INTRODUCTION

The index is divided into two parts: subject and author. Due to the selective and, therefore, limited number of abstracts appearing in ASSET, the index has been designed to provide access to specific material as well as to introduce readers to the full spectrum of information available in ASSET.

On the next page an OUTLINE is given of the subject index. It follows the general format and material arrangement of the regular issues of ASSET, however, there are some additions and modifications to render the volume of information more manageable.

Following the OUTLINE is a KEYWORD INDEX which will direct the reader to the locations of specific items within the SUBJECT INDEX. To use this KEYWORD INDEX, look up the specific word of interest and refer to the indicated section and the page of the SUBJECT INDEX on which this section begins.

Each section of the SUBJECT INDEX is arranged in order of the ASSET abstract number. The full titles, and issue and abstract numbers are listed. The material in parenthesis following a slash, /, after the title is not part of the title, but has been added to provide, when useful, more specific information about the contents of the reference.

OUTLINE FOR SUBJECT INDEX

A. GENERAL

GENERAL 7
GEOGRAPHICAL AREAS 7
COUNTRIES 7
VILLAGE PROJECTS 11

B. SOLAR ENERGY

GENERAL 11
RADIATION MEASUREMENT 12
SELECTIVE FILMS AND SURFACES 12

COLLECTORS AND CONCENTRATORS

GENERAL 13
NON-CONCENTRATING COLLECTORS 13
CONCENTRATORS 13
CONCENTRATOR-COLLECTOR SYSTEMS 13

PHOTOVOLTAIC CONVERSION

GENERAL 14
SILICON SOLAR CELLS 14
GaAs SOLAR CELLS 15
OTHER SOLAR CELLS 15
CELL FABRICATION 16
CONCENTRATORS FOR SOLAR CELLS 16
PUMPING SYSTEMS 16
OTHER PHOTOVOLTAIC SYSTEMS 16
COST AND ECONOMICS 16

THERMAL SYSTEMS

GENERAL 17
PUMPS AND POWER SYSTEMS 17
WATER HEATERS 17
SPACE HEATERS 18
SPACE COOLERS AND REFRIGERATORS 18
ARCHITECTURE 19
SOLAR PONDS 19
COOKERS 19
DRYERS 19
DESALINATION AND DISTILLATION 20
GREENHOUSES 20
OTHER SYSTEMS 20

C. BIOCONVERSION ENERGY

GENERAL 20

BIOMASS PRODUCTION AND CONVERSION

HYDROCARBON PRODUCING PLANTS 21
LAND PLANTS 21
WATER PLANTS 22
RESIDUES 22
ENERGY PLANTATIONS 22
ALCOHOL 22
WOOD FUEL 23

BIOGAS PRODUCTION AND UTILIZATION

GENERAL 23
BIOGAS PRODUCTION FROM PLANTS 23
BIOGAS PRODUCTION FROM RESIDUES 23
EQUIPMENT, DIGESTER DESIGNS AND PROCESSES 24

D. WIND ENERGY

GENERAL 24
DESIGNS 25
APPLICATIONS 25

E. ENERGY STORAGE

GENERAL 25
SENSIBLE HEAT STORAGE 26
LATENT HEAT, CHEMICAL AND ELECTRICAL STORAGE 26

F. SOCIO-ECONOMIC ASPECTS

SOCIAL ASPECTS 27
ECONOMIC ASPECTS 27
ENVIRONMENTAL ASPECTS 28
RURAL DEVELOPMENT ASPECTS 28

KEYWORD INDEX

A

Absorbent coating	B - SELECTIVE FILMS AND SURFACES	12
Absorbers	B - SELECTIVE FILMS AND SURFACES	12
	B - COLLECTORS AND CONCENTRATORS	13
Absorption refrigeration	B - Space Coolers and Refrigerators	18
Agricultural dryer	B - Dryers	19
Agricultural residues	C - BIOMASS PRODUCTION AND CONVERSION - Residues	22
	C - Biogas Production from Residues	23
Air conditioning	B - Space Coolers and Refrigerators	18
Air heating systems	B - Non-concentrating Collectors	13
	B - Space Heaters	18
	B - Architecture	19
AlGaAs-GaAs solar cell	B - GaAs Solar Cells	15
Alcohol production	C - BIOMASS PRODUCTION AND CONVERSION	21
	C - Alcohol	22
Algae	C - Water Plants	22
Algae pond	C - Water Plants	22
Amorphous silicon	B - Silicon Solar Cells	14
Anaerobic digestion	C - BIOGAS PRODUCTION AND UTILIZATION	23
Anaerobic fermentation	C - BIOGAS PRODUCTION AND UTILIZATION	23
Anti-reflective (AR) coating	B - SELECTIVE FILMS AND SURFACES	12
	B - COLLECTORS AND CONCENTRATORS	13
Arid regions	A - Geographical Areas	7
Array (solar array)	B - PHOTOVOLTAIC CONVERSION	14

B

Back-surface-field (solar cell)	B - Silicon Solar Cells	14
Battery (electrochemical)	E - Latent Heat, Chemical and Electrical Storage	26
Bio-energy	C - BIOCONVERSION ENERGY	20
Black chromium (selective absorber)	B - SELECTIVE FILMS AND SURFACES	12
Black nickel (selective absorber)	B - SELECTIVE FILMS AND SURFACES	12
Brackish water (desalination)	B - Desalination and Distillation	20

C

Cadmium sulphide (CdS) solar cell	B - Other Solar Cells	15
Cadmium telluride (CdTe) solar cell	B - Other Solar Cells	15
Chemical storage (of heat)	E - Latent Heat, Chemical and Electrical Storage	26
Chromium black	B - SELECTIVE FILMS AND SURFACES	12
Coatings	B - SELECTIVE FILMS AND SURFACES	12
	B - COLLECTORS AND CONCENTRATORS	13
Compound paraboloid concentrator	B - Concentrators	13
	B - Concentrator-Collector Systems	13
Compression refrigeration	B - Space Coolers and Refrigerators	18
Concentrating collector	B - Concentrator-Collector Systems	13
Concentrator	B - Concentrators	13
	B - Concentrators for Solar Cells	16
Cooling (refrigeration)	B - Space Coolers and Refrigerators	18
CPC Collectors	B - Concentrators	13
	B - Concentrator-Collector Systems	13
Cr-MIS solar cell	B - Silicon Solar Cells	14
Crop dryer	B - Dryers	19
Cu_2S-CdS solar cell	B - Other Solar Cells	15
Cylindrical absorber	B - COLLECTORS AND CONCENTRATORS	13
Cylindrical-trough collector	B - Concentrator-Collector Systems	13
Czochralski process for silicon crystal growth	B - Silicon Solar Cells	14
	B - Cell Fabrication	16

D

Desalination of water	B - Desalination and Distillation	20
	D - Applications	25
Digester	C - Equipment, Digester Designs and Processes	24

Dish concentrator	B - Concentrators	13
	B - Concentrator-Collector Systems	13
Distillation of water	B - Desalination and Distillation	20
E		
Edge-defined film-fed growth (EFG)	B - Silicon Solar Cells	14
	B - Cell Fabrication	16
Electrodialysis	D - Applications	25
Electrolysis	D - Applications	25
Encapsulation (of solar cells)	B - Cell Fabrication	16
Environment	F - Environmental Aspects	28
Epitaxially grown silicon solar cell	B - Silicon Solar Cells	14
	B - Cell Fabrication	16
Ethanol	C - BIOMASS PRODUCTION AND CONVERSION	21
	C - Alcohol	22
Evaporative cooling	B - Space Coolers and Refrigerators	18
F		
Fermentation	C - BIOCONVERSION ENERGY	20
Flash distillation	B - Desalination and Distillation	20
Flat-plate collector	B - Non-concentrating Collectors	13
Focussing collector	B - Concentrator-Collector Systems	13
Food dryers	B - Dryers	19
Food warmer	B - Cookers	19
Fresnel lens	B - Concentrators	13
	B - Concentrators for Solar Cells	16
Fuel cell	E - Latent Heat, Chemical and Electrical Storage	26
G		
Gallium arsenide solar cells	B - GaAs Solar Cells	15
Gobar gas	C - BIOGAS PRODUCTION AND UTILIZATION	23
H		
Heat collector	B - COLLECTORS AND CONCENTRATORS	13
	B - Water Heaters	17
	B - Space Heaters	18
Heat-of-fusion storage	E - Latent Heat, Chemical and Electrical Storage	26
Heat pump	B - THERMAL SYSTEMS - Other Systems	20
Heat storage	E - Sensible Heat Storage	26
Heterojunction solar cells	B - PHOTOVOLTAIC CONVERSION	14
Homojunction solar cells	B - PHOTOVOLTAIC CONVERSION	14
Honeycomb collectors	B - Non-concentrating Collectors	13
I		
Ice maker	B - Space Coolers and Refrigerators	18
Insolation calculation	B - RADIATION MEASUREMENT	12
Insolation measurement	B - RADIATION MEASUREMENT	12
Irrigation	B - PHOTOVOLTAIC CONVERSION - Pumping Systems	16
	B - THERMAL SYSTEMS - Pumps and Power Systems	17
L		
Linear focussing collector	B - Concentrator-Collector Systems	13
Linear parabolic collector	B - Concentrator-Collector Systems	13
Linear parabolic concentrator	B - Concentrators	13
M		
Methane digestion plant	C - Equipment, Digester Designs and Processes	24
Methane production	C - BIOGAS PRODUCTION AND UTILIZATION	23
MIS silicon solar cell	B - Silicon Solar Cells	14
MOS silicon solar cell	B - Silicon Solar Cells	14
Multi-junction solar cell	B - PHOTOVOLTAIC CONVERSION	14
Multi(ple)-stage flash distillation	B - Desalination and Distillation	20

N		
Nickel black	B - SELECTIVE FILMS AND SURFACES	12
Non-focusing concentrator	B - Concentrators	13
O		
Oven	B - Cookers	19
P		
Parabolic dish concentrator	B - Concentrators	13
	B - Concentrator-Collector Systems	13
Parabolic trough concentrator	B - Concentrators	13
	B - Concentrator-Collector Systems	13
Parabolic trough reflector	B - Concentrators	13
Passive cooling systems	B - Space Coolers and Refrigerators	18
Passive heating systems	B - Water Heaters	17
	B - Space Heaters	18
Photocell	B - PHOTOVOLTAIC CONVERSION	14
Photogalvanic cell	B - PHOTOVOLTAIC CONVERSION - General	14
Plantations (biomass)	C - Energy Plantations	22
Polycrystalline silicon solar cells	B - Silicon Solar Cells	14
Pumps	B - PHOTOVOLTAIC CONVERSION - Pumping Systems	16
	B - THERMAL SYSTEMS - Pumps and Power Systems	17
Pyradiometer	B - RADIATION MEASUREMENT	12
Pyranometer	B - RADIATION MEASUREMENT	12
Pyrgeometer	B - RADIATION MEASUREMENT	12
Pyrheliometer	B - RADIATION MEASUREMENT	12
Pyrolytic conversion	C - BIOCONVERSION ENERGY	20
R		
Rankine engine	B - THERMAL SYSTEMS - Pumps and Power Systems	17
	B - Space Coolers and Refrigerators	18
Reflector	B - Concentrators	13
Refrigeration	B - Space Coolers and Refrigerators	18
Ribbon cells	B - Silicon Solar Cells	14
	B - Cell Fabrication	16
Rock-bed storage	E - Sensible Heat Storage	26
S		
Savonious rotor	D - WIND ENERGY	24
Schottky barrier silicon solar cell	B - Silicon Solar Cells	14
Selective coating	B - SELECTIVE FILMS AND SURFACES	12
Si solar cell	B - Silicon Solar Cells	14
Single-crystal silicon solar cell	B - Silicon Solar Cells	14
Space cooling	B - Space Coolers and Refrigerators	18
Space heating	B - Space Heaters	18
Sterilizers	B - THERMAL SYSTEMS - Other Systems	20
Still	B - Desalination and Distillation	20
Stirling engine	B - THERMAL SYSTEMS - Pumps and Power Systems	17
	C - Equipment, Digester Designs and Processes	24
Stored energy	E - ENERGY STORAGE	25
Stove	B - Cookers	19
T		
Thermal storage	E - Sensible Heat Storage	26
Tracking concentrators	B - Concentrator-Collector Systems	13
W		
Water pumping	B - PHOTOVOLTAIC CONVERSION - Pumping Systems	16
	B - THERMAL SYSTEMS - Pumps and Power Systems	17
Wind generator	D - Applications	25
Wind mills	D - WIND ENERGY	24
Winston collector (compound parabolic concentrator)	B - Concentrators	13
	B - Concentrator-Collector Systems	13

A. GENERAL

GENERAL

Energy resources in the CDCC member countries/(Caribbean nations).	1-002
Energy for world agriculture/(prospects of renewable energy).	2-057
Energy dilemmas in Asia: the needs for research and development.	2-058
Food, energy and society/(historical review).	2-113
Food or fuel: new competition for world's cropland/(alcohol production).	2-114
Energy needs, uses and resources in developing countries.	3-117
Relevance of energy to the agricultural sector.	3-119
Energy related activities of the World Bank/(for small communities and rural areas of developing countries).	3-120
Erosion, deforestation and the loss of productivity.	4-281
Energy futures in developing countries.	5-286
Energy in a finite world - Volume I. Paths to a sustainable future.	5-287
Patterns of energy consumption among the urban and rural poor in developing countries.	5-360
Food versus fuel: competing uses for cropland.	6-412
Energy options for the Third World.	8-416
Energy in a finite world - Volume 2. A global systems analysis.	8-419
Proceedings of international workshop on energy survey methodologies for developing countries/(with annotated bibliography of 52 surveys).	8-423
Energy and aid.	8-487
Household energy use in non-OPEC developing countries.	9-492
Technology assessment: the case of the direct use of solar energy.	9-493
Rural energy and development: a strategic planning analysis.	9-571
The future of renewable energy in developing countries.	10-581

GEOGRAPHICAL AREAS

Energy resources in the CDCC member countries/(Caribbean nations).	1-002
Solar energy for rural development in the Asia and Pacific region.	1-004
Potential of large-scale algal culture for biomass and lipid production in arid lands/(marine and brackish water and sewage-tolerant micro-algae).	1-042
Energy dilemmas in Asia: the needs for research and development.	2-058
Thermal applications of solar energy/(arid zones; flat-plate collectors and water heaters).	2-080
Biological solar energy conversion for fuels/(R&D for Sahel region).	2-096
The ITDG international windpump programme: engineering design considerations used in developing a windmill system for small-scale manufacture and use in under-developed arid or semi-arid regions.	2-108
Energy crops: a new challenge for tropical regions/(charcoal, alcohol and vegetable-oil production).	3-166
Solar-based agricultural systems for the Middle East/(environmental-control systems).	4-243
Renewable sources of energy - Volume II. Biogas directory/(ESCAP region).	8-472
Engineering considerations in implementation of novel energy concepts/(windmills and flat-plate collectors in Sahara).	9-491
Solar energy, water and industrial systems in arid lands: techno-ecological overview and annotated bibliography.	10-585
Passive cooling systems in hot arid regions/(wind towers).	10-615
Arid land plants: promising new tools for economic development and basic research.	10-623

COUNTRIES (ALPHABETICAL ORDER)

AUSTRALIA

Your solar energy home, including wind and methane applications.	4-202
Hydrocarbon fuels from plants/(algae (*Botryococcus braunii*)).	8-465

BANGLADESH

Social structure and rural energy technology.	10-643

BOTSWANA

Appropriate technology in Africa/(Botswana, Swaziland and Lesotho).	10-580
Biogas in Botswana/(a 600-l horizontal plug-flow digester).	10-627

BRAZIL

The Brazilian alcohol program: a successful use of an alternative source of energy.	1-041
Biological solar energy conversion for fuels/(R&D programmes).	2-096
Solar perspectives: new world Brazil, energy leader.	3-118
Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden.	3-163
Energy crops: a new challenge for tropical regions/(case studies conducted in Brazil).	3-166
Which alcohol fuel for Brasil, methanol or ethanol?	4-254
Prospects of power generation from	4-283

solar plants in the northeast of Brazil.
Alternative new energy options for Brazil/(economics and state-of-technology). 6-365
Household energy use in non-OPEC developing countries. 9-492

CANADA

Biological solar energy conversion for fuels/(R&D programmes). 2-096
Your solar energy home, including wind and methane applications. 4-202

CHINA

Solar energy research and application in China. 1-005
Biological solar energy conversion for fuels/(R&D programmes). 2-096
The Chinese development of biogas and its applicability to East Africa. 3-175
China taps the wind to provide power in remote areas. 3-182
Solar energy research and application in China. 4-205
Guidebook on biogas development. 4-259
A dome-biogas plant with separate gas holder - a system under experiment in China. 4-262
China votes for the sun. 8-424
Biogas for the rural community in mainland China. 8-473
The construction of simple biogas digesters in the province of Szechwan, China. 9-551
Biogas in China: small-scale decentralized anaerobic digestion. 9-552

FRANCE

Energy and aid. 8-487

FED. REP. OF GERMANY

Wind and solar-powered reverse osmosis desalination units - description of two demonstration projects/(low-maintenance requirements for areas with poor infrastructure). 4-201
Energy and aid. 8-487

GUATEMALA

Household energy use in non-OPEC developing countries. 9-492

INDIA

A three year review/(Shri AMM Murugappa Chettiar Research Centre). 1-001
Preliminary studies of a low fuel, hop drying kiln for Himachal Pradesh, India. 1-035
Energy options: changing views from India. 1-054
Energy use in rural India/(a partially closed energy eco-system description). 1-055
Biological solar energy conversion for fuels/(R&D programmes). 2-096
The community factor in community biogas plant. 2-115
A simple solar cooker from India. 3-159
Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden. 3-163
Wind mills for rural India. 3-183
Economics of small solar power plants/(5 to 25 kW). 3-199
Self-reliant development - an IFIAS sponsored study/(systems-simulation technique). 4-200
Natural and thermal environmental control of houses in northern India. 4-207
Passive solar heating - improved living conditions for a high altitude population/(Ladakh, India). 4-239
A novel kind of fuel and fertilizer/(use of waste plants to make dried cakes by a fermentation process). 4-258
Design analysis of small-scale anaerobic digesters in India. 4-261
Irrigation for very small farmers: Appropriate technology or appropriate organization?/(especially windmill use). 4-270
Program and progress of DST sponsored solar photovoltaic work in India. 5-304
Photovoltaic power systems market identification and analysis. Appendices. 5-312
Biogas technology and utilisation - a status report. 5-342
Electrochemical storage of photovoltaic solar energy/(with specific information for India). 5-356
Social forestry in India/(planting trees by all people wherever possible. 5-361
Domestic energy consumption in India (Pondicherry region). 6-364
Biogas technology in the Third World: a multi-disciplinary review. 6-403
Renewable energy research in India/(directory of programmes). 8-421
Techno-economic felling cycles for selected energy plantation species in the arid areas of western Rajasthan. 8-468
Family and community biogas plants in rural India. 8-474
Integrated rural energy plan: a case study of a typical village in Kutch district of Gujarat state. 9-489
Household energy use in non-OPEC developing countries. 9-492
Indian solar energy resources index, 1975-1979/(bibliography of 746 items). 9-496
An Indian village agricultural ecosystem - case study of Ungra village, Part I: Main observation. 10-577
An Indian village agricultural ecosystem - case study of Ungra village, Part II: Discussion. 10-578

INDONESIA

Introducing solar powered solvent extraction of coconut oil in Panjang Rejo, a village in central Java, Indonesia. 2-088
Methane digesters in remote rural areas/(family-size digesters). 3-176
Biogas for Javanese villages: the products of digestion. 4-265
Biogas technology in the Third World: a multi-disciplinary review. 6-403

IRAN

Performance of natural ice makers/(traditional Iranian system). 1-031
Experimental and theoretical performance study of solar collectors. 3-153
Solar energy R&D in Iran: the approach and the philosophy. 5-291
Photovoltaic power systems market identification and analysis. Appendices. 5-312
Passive cooling systems in Iranian architecture/(traditional systems). 8-462
Conceptual development of a solar town in Iran. 9-490
Study of the effluents from the combustion of solid waste material. 9-575

ISRAEL

A system for the utilization of agricultural wastes in an agro-industrial settlement - kibbutz as a model. 8-475
Solar energy experience in Israel: a case study. 9-495

IVORY COAST

Solar energy: about new energies. 5-289

JAPAN

Natural energy sources and agriculture. 3-121
Japanese style utilization of solar heat boxes/(for hot-water bottles, braziers, and foot warmers). 5-331
Methane production from animal wastes and its prospects in Japan. 5-345
Report of a visit to agricultural research stations using solar energy systems. 6-369
Biogas technology in the Third World: a multi-disciplinary review. 6-403
Energy and aid. 8-487

JORDAN

Harnessing the Mideast sun/(solar energy programme in Jordan). 3-122
Solar sea water desalination for Arab countries. 4-240

KENYA

The Chinese development of biogas and its applicability to East Africa. 3-175
Energy resources in Kenya and their environmental impacts. 9-574
Energy and development: the case of Kenya. 10-576
Rural energy needs and alternative sources/(emphasis on Kenya). 10-582

KUWAIT

Status and prospects of local solar heating and cooling systems. 1-007

LESOTHO

Appropriate technology in Africa/(Botswana, Swaziland and Lesotho). 10-580

MALAWI

A four-bladed CSC windpump from Malawi. 3-184

MALAYSIA

Household energy use in non-OPEC developing countries. 9-492

MEXICO

The experiment in San Rafael, S.L.P./(windmill for pumping, grinding and milling). 1-050
Thermal applications of solar energy/(arid zones; flat-plate collectors and water heaters). 2-080
Solar energy programme at the Institute of Engineering of the National University of Mexico. 3-123
Wind and solar-powered reverse osmosis desalination units - description of two demonstration projects/(low-maintenance requirements for areas with poor infrastructure). 4-201
Photovoltaic power systems market identification and analysis. Appendices. 5-312
Photovoltaic cells: transforming the sun's rays into electricity/(technologies for industry). 8-441
Household energy use in non-OPEC developing countries. 9-492

MOROCCO

Morocco energy study/(oil shale, hydropower, solar and biomass). 8-422

NEPAL

Saving Nepal's dwindling forests/(hydropower and biogas). 5-288
Solar water heaters in a developing country. 5-318
Projected integrated farm in Nepal. 8-417
A commercial approach to biogas extension in Nepal. 9-554
Social structure and rural energy technology. 10-643

NETHERLANDS

Energy and aid. 8-487

NEW ZEALAND

Biological solar energy conversion for fuels/(R&D programmes). 2-096
Your solar energy home, including wind and methane applications. 4-202

NICARAGUA

Electricity from the sugar cane industry in Nicaragua. 8-464

NIGER

Solar energy: about new energies. 5-289

NIGERIA

Economic feasibility of gasification in Nigeria. 9-550

PAKISTAN

Pakistan's approach to the development of renewable energy - its resources and problems. 8-420
Household energy use in non-OPEC developing countries. 9-492

PERU

Solar drying potatoes/(using wind and solar energy). 5-328
Assessment of Peruvian biofuel resources and alternatives. 6-400
A methodology for assessment of biofuel resources in developing countries. 10-621

PHILIPPINES

Biological solar energy conversion for fuels/(R&D programmes). 2-096
Demonstration of anaerobic biogas digesters in developing countries. Part III. The Philippines. 5-343
Coconut husk-fueled pilot plant put to test/(producer gas). 6-401
Biogas technology in the Third World: a multi-disciplinary review. 6-403
Dendro-thermal power plants vs. oil-fired power plants under Philippine conditions/(using wood from a plantation of giant ipil-ipil trees). 10-626

REPUBLIC OF KOREA

Biogas technology in the Third World: a multi-disciplinary review. 6-403
Household energy use in non-OPEC developing countries. 9-492

SAUDI ARABIA

Solar-based agricultural systems for the Middle East/(environmental-control systems). 4-243
Greenhouses in hot climate. 6-398

SENEGAL

Solar energy: about new energies. 5-289

SPAIN

Investigation of sea water desalination plants in Spain. 2-089
Performance study of a solar still in Valencia (Spain). 3-157

SRI LANKA

A charcoal stove from Sri Lanka. 5-341

SUDAN

Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden. 3-163
Household energy use in non-OPEC developing countries. 9-492
A solar brick-drying experiment. 9-536

SWAZILAND

Appropriate technology in Africa/(Botswana, Swaziland and Lesotho). 10-580

SWEDEN

Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden. 3-163

TANZANIA

Feasibility study of windmills for water supply in Mara region, Tanzania. 1-049
Social and economic aspects of the introduction of gasification technology in the rural areas of the developing countries, e.g. Tanzania. 2-116
Windpower programmes in Tanzania. 9-560
Social and economical aspects of the introduction of gasification technology in the rural areas in the developing countries. 10-642

THAILAND

Biogas technology in the Third World: a multi-disciplinary review. 6-403

TURKEY

Greenhouses oriented to the sun (for more and early production). 1-036
Application of solar flat plate collector in Turkey. 2-083

UNITED KINGDOM

Your solar energy home, including wind and methane applications. 4-202
Engineering considerations in implementation of novel energy concepts/(for scattered low-density communities; windmills and flat-plate collectors). 9-491

UPPER VOLTA

Photovoltaic power system reliability considerations.	8-443
Solar cells move into new applications/(village power production).	9-516
Photovoltaic power system reliability considerations.	9-517

USA

Biological solar energy conversion for fuels/(R&D programmes).	2-096
Production cost analysis of Euphorbia lathyris. Final report.	2-101
Economic and kinetic studies of the production of chemicals and farm energy by fermentation of biomass.	2-105
Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden.	3-163
Your solar energy home, including wind and methane applications.	4-202
Deep-well solar irrigation experiment/(solar thermal system).	4-228
Chemicals from biomass - the U.S. prospects for the turn of the century.	4-252
An overview of bio-energy projects in the United States.	5-334
Methane on the move. A discussion of small anaerobic digesters. Final report/(portable demonstration trailer in western USA).	5-347
American Indian projects in solar energy: community involvement.	8-425
Solar powered irrigation and the NML/Battelle solar pump.	8-454
Enhanced energy production and water refuse for swine operation in Hawaii.	8-476
Energy and aid.	8-487
Solar cells move into new applications/(village power production).	9-516

USSR

Photosynthesis research in the USSR.	1-039
Use of solar radiation for creating comfortable temperature conditions in Turkmenian SSR.	2-087
Intensifying the killing and drying process for silk cocoons with the aid of solar energy.	4-245

ZAIRE

Solar energy: about new energies.	5-289

ZAMBIA

Social structure and rural energy technology.	10-643

VILLAGE PROJECTS

A three year review/(biogas, wind and solar energy, and food production system in India).	1-001
The experiment in San Rafael, S.L.P./(windmills in Mexico).	1-050
Self-reliant development - an IFIAS sponsored study/(system-simulation study of village system in India).	4-200
Projected integrated farm in Nepal/(crop-livestock agro-processing complex using bioconversion and solar energy).	8-417
American Indian projects in solar energy: community involvement.	8-425
Integrated rural energy plan: a case study of a typical village in Kutch district of Gujarat state/(India).	9-489
Conceptual development of a solar town in Iran.	9-490
Solar cells move into new applications/(village power production in USA, Upper Volta).	9-516
Integrated energy system for non-electrified rural communities/(low-cost biomass, solar, wind and micro-hydroelectric systems).	10-579

B. SOLAR ENERGY

GENERAL

A three year review/(Shri AMM Murugappa Chettiar Research Centre in India).	1-001
Energy resources in the CDCC member countries/(Caribbean nations).	1-002
Solar energy for rural development in the Asia and Pacific region.	1-004
Energy for world agriculture/prospects for renewable energy).	2-057
Energy alternatives for the year 2000/(wind and biomass energy for rural self sufficiency).	2-060
Global aspects of sunlight as a major energy source.	2-061
Some solar energy programs in the United Nations system.	2-062
Solar energy: past and present developments.	2-063
Energy needs, uses and resources in developing countries.	3-117
Energy related activities of the World Bank/(for small communities and rural areas of developing countries).	3-120
Natural energy sources and agriculture/(Japan).	3-121
Solar technology: fundamentals, applications, and future outlook/(for contending with energy bottlenecks).	3-125
Ecological considerations of the solar alternatives.	3-197
Self-reliant development - an IFIAS sponsored study/(systems-simulation of technologies in India).	4-200
Energy futures in developing countries.	5-286
Energy in a finite world - Volume I. Paths to a sustainable future.	5-287
Solar energy: about new energies.	5-289

Patterns of energy consumption among the urban and rural poor in developing countries.	5-360
Potential of renewable energies in planning the development of rural areas.	6-366
Food versus fuel: competing uses for cropland.	6-412
Utilization of small-scale solar energy for rural development: a strategy.	6-413
New village uses of renewable energy sources.	8-418
Energy in a finite world - Volume 2. A global systems analysis.	8-419
Proceedings of international workshop on energy survey methodologies for developing countries/(with annotated bibliography of 52 surveys).	8-423
Energy and aid.	8-487
Technology assessment: the case of the direct use of solar energy.	9-493
Solar energy utilization/(costs and benefits of many systems).	9-494
Rural energy and development: a strategic planning analysis.	9-571
Integrated energy system for non-electrified rural communities.	10-579
The future of renewable energy in developing countries.	10-581
Perspective on developing country solar energy applications/(inventories for development).	10-583
Solar energy, water and industrial systems in arid lands: techno-ecological overview and annotated bibliography.	10-585

RADIATION MEASUREMENT

Solar radiation instruments.	2-072
Experimental investigation of an inexpensive sky temperature measuring device.	3-132
Calibration of solar radiation measuring instruments.	4-215
Inexpensive portable Cu_2S - CdS radiometer.	5-301
Instrumentation for solar radiation measurements/(survey).	8-433
Infrared radiation measurements.	9-506
Inexpensive, portable, integrating solar energy meter.	10-592

SELECTIVE FILMS AND SURFACES

Low cost, durable anti-reflective film for solar collectors/(acid-hardened sodium-silicate solutions).	1-010
Techniques of selective coating/(electro-deposition).	2-067
Experimental methods for the preparation of selectively absorbing textured surfaces for photothermal solar conversion/(dendritic, porous and granular).	2-068
$CuGa_xIn_{1-x}Se_2$ thin films for solar cells prepared by flash-evaporation.	2-076
Low cost electroless nickel black coatings for photothermal conversion.	3-127
Optical and electrical investigations on annealed indium oxide selective coatings produced by spray pyrolysis.	3-128
Possibility of black zinc oxide as spectrally selective coatings for low temperature solar collectors.	3-129
Selective surfaces for copper solar absorbers.	3-130
Selective coating for solar water heaters/(NiS-ZnS and copper oxide).	3-149
A study of two binary eutectic aluminium alloys as selective absorbers for solar photothermal conversion/(Al-6% Ni and Al-33% Cu).	4-211
Development of selective coatings for solar photothermal absorbers: electro-deposited black nickel.	4-212
Solar selective properties of some plated coatings/(nickel, zinc).	4-213
Tin oxide as a spectral selective coating on enamel.	4-214
Dendritic tungsten for solar thermal conversion.	5-294
New approach to low cost large area selective surfaces for photothermal conversion/(CuO, CuS, PbS + CuS).	5-295
Spectral selective properties of black chrome and nickel electrodeposited coatings for solar absorber.	5-296
Microstructural and mechanical property evaluation of zinc oxide coated solar collectors.	6-371
Selective surfaces/(basic physics and practical requirements).	6-372
Solar selective copper-black layers by an anodic oxidation process.	6-373
Antireflection coatings on metals for selective solar absorbers/(TiO_x-Ti).	6-374
Low-temperature solar coatings.	8-427
Structured coatings for solar energy collectors/(Ni or Co electroplated on Al, MS or Cu).	8-428
The selective solar absorptance of in situ-grown oxide films on metals.	8-429
Nickel pigmented anodic aluminium oxide for selective absorption of solar energy.	8-430
Spectrally selective solar absorber coatings.	9-499
Low-cost solar antireflection coatings. Annual report, 24 July 1978-24 September 1979.	9-501
Solution growth of CdSe and PbSe films.	9-502
A comparison of thermal performance of austenitic stainless steel solar absorber plates coloured by chemical and thermal oxidation techniques.	9-503
Spectrally selective copper sulphide coatings/(aluminium substrates).	10-587
Selective transparent filters produced by optical multilayer coatings/(MgF_2 and thin metal film).	10-588

Aluminium or copper substrate panel for selective absorption of solar energy.	10-589
A new approach to low cost large area selective surfaces for photochemical conversion.	10-590

COLLECTORS AND CONCENTRATORS

GENERAL

Potentiality of glass in harnessing solar energy/(glass parts for collectors, exchangers and storage systems).	4-238
Dendritic tungsten for solar thermal conversion.	5-294
Silicon solar cell power supply with auto-tracker/(solar-powered tracking).	5-309
Plastic honeycomb solar coverplates.	6-370
Solar energy utilization/(costs and benefits of many systems).	9-494

NON-CONCENTRATING COLLECTORS

Cost-effective selection of flat-plate solar collectors/(comparison of 16 designs).	1-030
Thermal application of solar energy/(arid zones; flat-plate collectors, and water heaters).	2-080
Inflated flexible solar collectors.	2-082
Application of solar flat plate collector in Turkey.	2-083
Use of a honeycomb as solar radiation absorber and heat exchanger in an air-type solar collector.	2-085
Honeycomb heat trap: its application in flat plate solar collectors.	2-086
Performance of a flat plate collector for solar cooker.	2-094
Energetic efficiency of some particular types of flat plate collectors.	3-152
Experimental and theoretical performance study of solar collectors/(performance study of four types).	3-153
Performance of a honeycomb type flat-plate collector with a serpentine tube.	4-235
Performance of an inexpensive constant flow solar collector/storage system in ground/(network of buried plastic pipes).	4-236
Device for producing useful heat from solar radiation/(two rollable foils with heat-transfer liquid).	5-314
Performance evaluation of spiral solar collector.	5-316
Solar collector for rural use.	5-317
Thin-film solar collector/(for regions with broken cloud cover).	6-385
Technology of flat plate collectors.	8-444
Elementary properties of a reverse flat plate type solar heat collector developed for collecting total insolation.	8-445
Experiments on flow-down type solar heat collector.	9-521
Performance study of air-heated packed-bed solar-energy collectors/(using iron chips, aluminium chips, and pebbles).	9-522
Measurement of flat-plate collector heat loss coefficients.	9-523
Design and performance of an air collector for industrial crop dehydration/(90 °C range).	9-526
Heat collecting characteristics of reverse flat plate type solar heat collectors.	9-527
Studies into reduction of radiative heat losses of flat-plate solar collectors.	9-529
Roll-up device to generate useful heat from solar radiation.	10-607
Comparative performance testing of flat-plate solar water heaters.	10-610

CONCENTRATORS (excluding photovoltaic)

Simple solar tracking system/(falling weight, controlled by a pendulum).	1-009
Experimental and theoretical investigation of an east-west oriented parabolic concentrator.	4-209
Manufacture of Fresnel lens by radiation cast polymerization.	4-210
Performance test of a non-parabolic asymmetrical solar concentrator.	4-234
Silicon solar cell power supply with auto-tracker/(solar-powered tracking).	5-309
Concentrators for solar energy utilization/(review).	9-498
Use of thin glass reflectors for solar concentrators.	9-500
Fundamentals and techniques of non-imaging optics for solar energy concentration. Final report.	10-591
Fluorescent planar collector-concentrators: a review.	10-600

CONCENTRATOR-COLLECTOR SYSTEMS

Nontracking concentrating solar collector/(parallel parabolic-reflector segments).	1-008
Heat pipes for sun energy conversion.	1-037
Device at heating a liquid by solar energy/(fluid is part of lens).	2-066
Design and test of non evacuated solar collectors with compound parabolic concentrators.	2-070
Tubular solar collector/(black spiral plastic absorber).	3-150
Non-tracking moderately focusing heat pipe solar collector.	3-151
Preliminary results from a test array of 3X CPC collectors in a school heating application.	3-154
Approximations to the CPC - a comment on recent papers by Canning and by Shapiro.	4-208

Design and test of non-evacuated solar collectors with compound parabolic concentrators.	4-233
Residential solar designs using pyramidal optics solar systems.	4-237
Concentrators for solar energy utilization/(review).	9-498
Elliptical solar reflector.	9-528
Static solar tracker and energy converter/(fluid-containing tube with hemi-cylindrical reflector).	9-530
Solar energy collector device/(with longitudinal V-shaped reflectors).	10-608
Apparatus for the collection and conversion of solar energy/(with floating tracking system).	10-609
Development of a low-cost non-tracking heat pipe concentrating collector.	10-611
Characteristics of 3.5 m long heat pipe for solar collector.	10-612
Recent heat pipe applications at the CEN, Grenoble, France.	10-613

PHOTOVOLTAIC CONVERSION

GENERAL

Research in photovoltaic cells/(applications, materials and fabrication).	1-016
High efficiency, high density terrestrial solar panels/(rectangular arrays).	1-017
International photovoltaic program plan. Volumes I & II/(to promote systems internationally).	1-019
Novel concentrator photovoltaic converter system development. Final report, January 24-August 30, 1979/(30% efficiency cascade solar cell).	2-074
The physics and chemistry of solar cells.	3-133
MIS solar cells: a review.	3-134
Cascade solar cells.	3-138
Photovoltaics and environmental impact considerations/(Airport Solar Photovoltaic Concentrator Project).	3-196
Photovoltaic conversion of solar energy II/(technology and costs to 1995).	4-216
Solar energy: about new energies.	5-289
Survey of semiconductor combinations for optimum heterojunction thin film solar cells.	5-307
Silicon solar cell power supply with auto-tracker/(solar-powered tracking).	5-309
Direct energy conversion: an attractive option for developing countries) (Si, GaAs and Si-GaAs technology and costs).	6-377
Process to reduce the manufacturing cost of monocrystalline solar cells.	8-438
Photovoltaic cells: transforming the sun's rays into electricity/(technologies for industry).	
Transformation of solar radiation by fluorescence: application to the encapsulation of cells.	10-601

SILICON SOLAR CELLS

Photovoltaics: a review/(single-crystal silicon cells and systems).	2-073
The development of a high-efficiency silicon BSF type solar cell.	2-078
MIS solar cells: a review.	3-134
Recent developments in amorphous silicon cells/(glow-discharge deposition and cell structures).	3-135
Epitaxial silicon growth for solar cells. Final report.	3-136
Development of silicon solar cells for concentrated sunlight/(silicon n$^+$-p-p$^+$ solar cells: 30x).	3-137
Performance of silicon and gallium arsenide concentration cells.	3-139
Effect of heavy doping on the properties of high-low junction.	3-141
Low-cost high-efficiency SnO$_2$/n$^+$-p Si heteroface solar cell.	4-218
Forward- and reverse-bias tunnelling effects in n$^+$-p silicon solar cells.	4-219
Nonreflecting vertical junction silicon solar cell optimization. Final report, 15 May 1976-31 August 1978.	4-220
Single crystal silicon photocells for terrestrial use - state of the art and perspectives on the future/(cost reduction industrial manufacturing processes).	4-221
Loss mechanism analysis in single-crystal and polycrystalline silicon MIS solar cells to produce 13% efficiency.	4-222
Development of an improved high efficiency thin solar cell. Quarterly report.	5-306
Survey of semiconductor combinations for optimum heterojunction thin film solar cells.	5-307
Direct energy conversion: an attractive option for developing countries/(Si, GaAs and Si-GaAs cell technology and costs).	6-377
Study of ion implanted n$^+$ layers for silicon solar cells/(large, low-cost cells).	6-380
Efficient indium tin oxide/polycrystalline silicon semiconductor-insulator-semiconductor solar cells.	6-381
Performance of silicon solar cells in front of a water absorber.	6-383
Reliability studies on MIS and transparent oxide-Si solar cells.	8-437
Process to reduce the manufacturing cost of monocrystalline solar cells.	8-438
New technique for fabrication of pnn polycrystalline silicon solar cells by simultaneous diffusion of boron and phosphorus into silicon.	8-439
Silicon web process development. Low cost solar array project, large area silicon sheet task. Quarterly report, October 1, 1978-December 31, 1978.	8-440
Silicon solar cells. I. Basics.	9-507
Application of electrochemical methods in Ga$_{1-x}$Al$_x$As/GaAs solar cell fabrication/(for contact fingers).	9-509

Silicon solar cells by high-speed low-temperature processing/(ion implantation and pulsed electron beam).	9-512
High efficiency bifacial back surface field solar cells.	9-513
Development of high efficiency (14%) solar cell array module. Second quarterly report, March 15-July 15 1979.	9-514
Effect of abrasive jet machining (AJM) the edge on the performance of a polycrystalline silicon solar cell.	9-515
High efficiency silicon cells for luminescent solar concentrators.	10-595
Silicon solar cells. II. Practical aspects.	10-597
The silicon concentrator photovoltaic generator Sophocles: performance and costs based on material characteristics.	10-599

GaAs SOLAR CELLS

Photoelectric converters of concentrated solar radiation utilizing AlGaAs heterostructures.	1-013
GaAs-GaAlAs solar cells/(improved structure and fabrication process).	2-075
Large-area high-efficiency (AlGa)As-GaAs solar cells/(infinite-melt liquid-phase epitaxial process).	2-077
MIS solar cells: a review.	3-134
Cascade solar cells.	3-138
Performance of silicon and gallium arsenide concentration cells.	3-139
Development of high efficiency cascade solar cells. Quarterly technical progress report No. 2/(GaAlAs/GaAs, AlGaAsSb/GaAsSb and GaInP cells).	5-305
Survey of semiconductor combinations for optimum heterojunction thin film solar cells.	5-307
Direct energy conversion: an attractive option for developing countries/(Si, GaAs and Si-GaAs cell technology and costs).	6-377
High efficiency GaAs-GaAlAs solar cells for very high concentration systems.	6-379
Electrical properties of Zn^+-doped (AlGa)As prepared by molecular beam epitaxy and its use in shallow junction solar cells.	8-434
High efficiency GaAs solar cell development. Final report, 1 August 1976-1 July 1978.	8-435
High-efficiency thin-film GaAs solar cells/(CVD on recrystallized Ge films).	9-510
Investigation of heterojunction photocells with an intermediate energy conversion stage at high illumination intensities.	9-511
High efficiency $Al_xGa_{1-x}As$-GaAs solar cells with high open-circuit voltage and high fill factor.	10-594

OTHER SOLAR CELLS

Photochemical energy conversion studies in systems containing methylene blue.	1-011
CdS-CdTe solar cell prepared by vapor phase epitaxy.	1-014
Photovoltaic characteristics of chemically deposited photosensitive cells/($CuCl_2$ on brass, $ZnCl_2$ on Zn and $AlCl_3$ on Al).	1-015
Temperature effects in photoelectrochemical cells/(TiO_2 photoanode and O_2/OH redox electrolyte).	2-064
Direct photoelectrochemical conversion and storage of solar energy/(TiO_2 film photoanode and NaOH electrolyte).	3-131
The physics and chemistry of solar cells/(emphasis on $Cd_xZn_{1-x}S$-Cu_2S cells).	3-133
Cascade solar cells.	3-138
Sintered type cadmium sulphide-thallous sulphide heterojunction photovoltaic cells.	3-140
Studies on the improvement of performance of sintered Cu_2S/CdS solar cells/(In doping and reheating).	4-217
Electrochemical photovoltaic cells for solar energy conversion/(TiO_2-doped Fe_2O_3).	5-298
Photothermal effect at TiO_2 electrodes in a photoelectro-chemical cell.	5-299
Solar fuels/(photochemical conversion and storage).	5-300
Review of conductor-insulator-semiconductor (CIS) solar cells.	5-302
Advances in theory, fabrication, and applications of bifacial solar cells.	5-303
Development of high efficiency cascade solar cells. Quarterly technical progress report No. 2/(GaAlAs/GaAs, AlGaAsSb/GaAsSb and GaInP cells).	5-305
Survey of semiconductor combinations for optimum heterojunction thin film solar cells.	5-307
The test and use of thin film CdS solar cells under different load conditions.	5-310
Efficient and stable photoelectrochemical cells constructed with WSe_2 and $MoSe_2$ photoanodes.	6-375
Energy conversion through electrochemical solar cell based on CdS film photoanode.	6-376
Study on junction properties of n-CdS/p-InP heterodiodes by using injection electroluminescence.	6-378
Solar photoelectrolysis with semiconductor electrodes.	8-431
Photovoltaic conversion by macromolecular thionine films.	8-432
Photogalvanic cells/(Fe-Ru and Fe-thionine cells).	9-504
Saur vidyut kosh: the solar cell/(reversible solar galvanic cell).	9-505
n-CdS/p-$ZnIn_2Se_4$ thin film solar cell.	9-508
High-efficiency InP homojunction solar cells/(15% AM1).	10-593

Photovoltaic properties of thin film Cu_2Se-CdSe heterojunctions.	10-596

CELL FABRICATION

GaAs-GaAlAs solar cells/(improved structure and fabrication process).	2-075
Large-area high-efficiency (AlGa)As-GaAs solar cells/(infinite-melt liquid-phase epitaxial process).	2-077
Epitaxial silicon growth for solar cells. Final report.	3-136
High efficiency GaAs-GaAlAs solar cells for very high concentration systems.	6-379
High efficiency n-CdS/p-InP solar cells prepared by the close-spaced technique.	8-436
Process to reduce the manufacturing cost of monocrystalline solar cells.	8-438
New technique for fabrication of pnn polycrystalline silicon solar cells by simultaneous diffusion of boron and phosphorus into silicon.	8-439
Silicon web process development. Low cost solar array project, large area silicon sheet task. Quarterly report, October 1, 1978-December 31, 1978.	8-440
Application of electrochemical methods in $Ga_{1-x}Al_xAs$/GaAs solar cell fabrication/(for contact fingers).	9-509
Silicon solar cells by high-speed low-temperature processing/(ion implantation and pulsed electron beam).	9-512
High efficiency bifacial back surface field solar cells.	9-513

CONCENTRATORS FOR SOLAR CELLS

A novel square Fresnel lens design illuminating circular solar cells.	3-142
The development of photovoltaic conversion systems with sunlight concentration/(parabolic cylinder-type, compound-type and linear Fresnel type).	5-308
Novel solar cell concentrator photovoltaic converter system/(spectrum splitting and multi-band gap cells).	6-382
Concentrators for solar energy utilization/(review).	9-498
Performance of a photovoltaic concentractor module consisting of silicon solar cells with a facet cylindrical mirror COSS.	10-598
The silicon concentrator photovoltaic generator Sophocles: performance and costs based on material characteristics.	10-599
Fluorescent planar collector-concentrators: a review.	10-600
Transformation of solar radiation by fluorescence: application to the encapsulation of cells.	10-601
Luminescent solar concentrator (LCS): a diffuse sunlight concentrator for solar cells.	10-602

PUMPING SYSTEMS

Powering a submerged pump with a photovoltaic generator using a transistorized three phase inverter.	1-018
Technical and economic assessment of solar powered water pumping for remote areas. Final report.	2-065
The application of solar cells/(pumping, telecommunications, and rural electrification).	2-079
Economics of adopting solar energy systems for crop irrigation: comment.	4-282
Assessing solar photovoltaic energy systems for crop irrigation/(economic, technological and political).	5-362
Solar water pumping.	6-388
Solar cells move into new applications/(village power production in USA and Upper Volta).	9-516
NASA Lewis Research Center photovoltaic application experiments.	9-518

OTHER PHOTOVOLTAIC SYSTEMS

The application of solar cells/(pumping, telecommunications, and rural electrification).	2-079
Photovoltaic/thermoelectric refrigerator for medicine storage for developing countries.	5-293
Silicon solar cell power supply with auto-tracker/(solar-powered tracking).	5-309
Operation of DC motors powered by photovoltaic converters.	5-311
Electrochemical storage of photovoltaic solar energy.	5-356
Solar power for electrodialysis.	6-384
Photovoltaic power system reliability considerations.	8-443
Solar cells move into new applications/(village power production in USA and Upper Volta).	9-516
Photovoltaic power system reliability considerations.	9-517
NASA Lewis Research Center photovoltaic application experiments.	9-518

COST AND ECONOMICS

High efficiency, high density terrestrial solar panels/(rectangular arrays).	1-017
International photovoltaic program plan. Volumes I & II/(to promote systems internationally).	1-019
Economics of adopting solar energy systems for crop irrigation: comment.	4-282
Photovoltaic power systems market identification and analysis. Appendices.	5-312
Report of a visit to agricultural research stations using solar energy systems.	6-369
Direct energy conversion: an attractive option for developing countries/(Si, GaAs and Si-GaAs cell technology and costs).	6-377

Photovoltaic power sytems market identification and analysis. Volume II (of 2 volumes). 6-415

THERMAL SYSTEMS

GENERAL

Solar energy systems for continuous process/(air and water systems and agricultural processing). 2-081
Photothermal conversion of solar energy into electricity. 3-143
Strategy for the development of some low grade thermal devices/(water heaters and stills). 4-206
Potentiality of glass in harnessing solar energy. 4-238
Solar energy in theory and practice/(heating systems and architectural designs). 5-292
Dendritic tungsten for solar thermal conversion. 5-294
Plastic honeycomb solar coverplates. 6-370
Passive solar energy design and materials. 6-393
Solar energy utilization/(costs and benefits of many systems). 9-494
Experimental investigations of a physical system capable of using solar energy/(using low-temperature differences). 9-519
Improvement in the heat exchange performance. 9-569
Solar energy for agriculture: review of research. 10-586
Recent heat pipe applications at the CEN, Grenoble, France. 10-613
Methanolcalcium chloride chemical heat pump for small air conditioning. heating, and storage/(single unit). 10-614
Passive solar handbook. 10-616

PUMPS AND POWER SYSTEMS

Turbines and turbogenerators for solar power plants with thermodynamic cycles. 1-026
Technical and economic assessment of solar powered water pumping for remote areas. Final report. 2-065
Low-temperature thermal solar motor/(using low boiling-point liquid). 2-084
Power generation and potable water recovery from salinous water. 3-126
A low lift solar water pump/(intermittent Rankine cycle with freon-113). 3-145
Sandia Laboratories operational experience with small heat engines in solar thermal power systems. 3-147
Current costs of solar powered organic Rankine cycle engines. 3-198
Economics of small solar power plants/(rural 5-25 kW applications in India). 3-199
Deep-well solar irrigation experiment/(trough-type collectors and organic Rankine-cycle engine). 4-228
Solar water pumping. 6-388
Vapor turbine units with organic working fluids and prospects for their use in solar power generation: survey/(using solar, geothermal, and industrial waste heat sources). 6-391
Solar powered liquid piston Stirling cycle irrigation pump. 8-452
Steam turbine installations with organic working fluids, and the outlook for using them in solar engineering. 8-453
Solar powered irrigation and the NML/Battelle solar pump/(irrigation-system research programme in USA). 8-454
Design of a 150 kW solar-powered irrigation facility/(using 4550-m^2 field of parabolic trough collectors). 8-455
Correlations and transition regimes in a thermodynamic solar pump. 9-524
The thermodynamic cycle of the Minto solar wheel. 9-531
Solar energy for agriculture: review of research. 10-586
Modification of the intake-exhaust system of a MGS 2 x 1000 expansion motor in a Segal solar pump. 10-603

WATER HEATERS

Status and prospects of local solar heating and cooling systems. 1-007
Compact shallow solar pond hot water heater. 1-020
Pipe type solar water heating/(pipes absorb heat and store heated water, 67-70 °C). 1-021
Solar water heater with hemicylindrical boiler. 1-023
Solar hot water heater/(instructions for thermo-syphon domestic system). 1-024
A comparing analysis of six generic solar domestic hot water systems. 1-029
Thermal application of solar energy/(arid zones; flat-plate collectors, and water heaters). 2-080
Solar energy systems for continuous process/(air and water systems for agricultural processing). 2-081
Analytical and experimental study of pumped solar water heaters. 3-144
Selective coating for solar water heaters/(NiS-ZnS and copper oxide). 3-149
Strategy for the development of some low grade thermal devices/(water heaters and stills). 4-206
Low cost solar water heating for large scale applications/(black-bottom shallow solar ponds). 4-230
Solar energy in theory and practice. 5-292
Selective radiation properties of Indian plastics for solar heating and natural cooling of water/(polyvinyl chloride and polyethylene). 5-297

Production and use of rolled-welded panels of aluminum alloys for solar water heaters of hot water supply and cooling systems. 5-313
Experience with a large size solar hot water system/(cooling and hot water). 5-319
Japanese style utilization of solar heat boxes/(for hot-water bottles, braziers and foot warmers). 5-331
Solar water heaters and rural development/(natural-convection). 6-386
Solar water heater designed mainly aiming at the economical efficiency of installation cost/(flow-down type). 6-387
Heat-transmission device for solar heating systems. 8-446
The GFL method for sizing solar energy space and water heating systems. 8-451
Studies of a compact solar water heater/(90-l tank in India). 9-520
Comparative performance testing of flat-plate solar water heaters. 10-610
Methanolcalcium chloride chemical heat pump for small air conditioning, heating, and storage/(single unit). 10-614

SPACE HEATERS

Status and prospects of local solar heating and cooling systems. 1-007
Preliminary results from a test array of 3X CPC collectors in a school heating application. 1-022
Single room heating by solar radiation/(using stack effect). 1-025
Heating of building with solar energy/(review). 1-027
Analysis and performance of a south facing solar wall/(pipe heat exchange in blackened-glazed cement). 1-028
Solar space heating and air conditioning, volume 2, 1976-August 1977 (citations from the NTIS data base). 2-071
Solar energy systems for continuous process/(air and water systems for agricultural processing). 2-081
Utilization of hollow slabs in heating and cooling of buildings/(blackened pipes on hollow concrete slab). 3-148
Computer modeling of a ventilated Trombe wall - with actual performance results. 3-156
Passive solar heating - improved living conditions for a high altitude population/(Ladakh, India). 4-239
Solar energy in theory and practice. 5-292
Japanese style utilization of solar heat boxes/(for hot-water bottles, braziers and foot warmers). 5-331
Comparison between the performance of three different methods for storage and low temperature heat (solar heat) for space heating. 5-355
Heat storage in buildings: an overview. 5-357
Passive solar energy design and materials. 6-393
Heat-transmission device for solar heating systems. 8-446
Cheap roof type solar air heaters for industries. 8-450
The GFL method for sizing solar energy space and water heating systems. 8-451
Passive solar progress/(heating- and cooling-systems). 9-537
Comparison between the performance of three different methods for storage of low temperature heat (solarheat) for space heating. 9-566
Central storage for solar active space heating. 9-567
Solar energy for agriculture: review of research. 10-586

SPACE COOLERS AND REFRIGERATORS

Performance of natural ice makers/(traditional Iranian system). 1-031
Experimental study into cooling effect by nocturnal radiation to outer space for possible applications in rural areas. 1-033
Solar space heating and air conditioning, volume 2, 1976-August 1977 (citations from the NTIS data base). 2-071
Development and testing of an ammonia water absorption refrigeration system for a cold storage unit using solar energy). 3-146
Solar refrigeration utilizing zeolites. 3-162
Solar collector panel and refrigeration system operated thereby. 4-229
Open absorption system utilizing solar energy for air conditioning. 4-231
Selective radiation properties of Indian plastics for solar heating and natural cooling of water/(polyvinyl chloride and polyethylene). 5-297
Production and use of rolled-welded panels of aluminum alloys for solar water heaters of hot water supply and cooling systems. 5-313
Performance of an intermittent ammonia-water solar refrigerator operating with a flat plate collector. 5-320
The desiccant rock bed method of solar cooling with air collectors. 5-321
Energy storage for solar air conditioning applications utilizing a form-stable, high density polyethylene pellet bed. 5-358
Survey of existing solar powered refrigeration systems for storage of food stuffs and a method of calculation for solar-powered Platen-Munters system/(literature survey). 6-389
Liquid desiccant solar air conditioner and energy storage system/(water and triethylene glycol). 6-390
Passive solar energy design and materials. 6-393
Development of solar desiccant dehumidifier/(silica gel). 6-394

Performance of an experimental regenerative-evaporative cooler compared with predictions/(3.5 tonnes at 20 °C). 8-448
Preliminary tests of solar unit for reduction of heat content and evaporative cooling of air. 8-449
Proceedings of the desiccant cooling conference/(US DOE programmes). 8-461
Passive cooling systems in Iranian architecture/(traditional systems). 8-462
Solar cooling R and D overview. 9-497
Passive solar progress/(heating- and cooling-systems). 9-537
Solar energy for agriculture: review of research. 10-586
Experimental investigations of an intermittent ammonia-water solar refrigerator. 10-605
Methanolcalcium chloride chemical heat pump for solar air conditioning, heating, and storage/(single unit). 10-614
Passive cooling systems in hot arid regions/(wind towers). 10-615

ARCHITECTURE

Status and prospects of local solar heating and cooling systems. 1-007
Use of solar radiation for creating comfortable temperature conditions in Turkmenian SSR/(solar cooling). 2-087
Sun archi/(20 architectural designs). 3-124
Utilization of hollow slabs in heating and cooling of buildings/(blackened pipes on hollow concrete slab). 3-148
Design aids for particulate bed systems for summer cooling. 3-192
Natural thermal environmental control of houses in northern India. 4-207
Residential solar designs using pyramidal optics solar systems. 4-237
Passive solar heating - improved living conditions for a high altitude population/(Trombe-wall; Ladakh, India). 4-239
Experimental study of latent heat storage for houses. 4-279
Heat storage in buildings: an overview. 5-357
Encyclopedia of energy-efficient building design: 391 practical case studies. Volumes I and II. 6-367
Architectural design based on climate/(energy-conservation). 6-368
Survey of passive solar buildings. 6-392
Passive solar energy design and materials. 6-393
Architecture au naturel/(microclimate design of houses). 8-426
Solar energy utilization/(costs and benefits of many systems). 9-494
Passive designs for desert houses. 9-538

SOLAR PONDS

Solar energy collecting pond/(power and/or desalination). 1-012
Solar pond concepts: old and new/(survey, classification and synthesis of concepts). 2-091
Model stratified layer solar pond with enhanced heat storage/(black containers of hydrates in pond). 2-092
Low cost solar water heating for large scale applications/(black-bottom shallow solar ponds). 4-230
Solar ponds for industrial process heat/(can washing and laundry). 4-232
Implementation of a solar pond greenhouse heating system. 4-246
Cost reductions and performance improvements for shallow solar ponds. 4-247
The use of sodium sulphate in solar ponds/(to impede salt diffusion). 5-325
A simple method to establish salt gradient solar ponds/(by injection of fresh water). 5-326
Sede Boqer, shallow solar ponds project/(lower black PVC sheet and transparent cover). 5-327
Performance of a large, salt-gradient solar pond/(2000 m^2). 8-458
Non-convecting solar ponds/(1-km^2 MgCl pond). 8-459
Low temperature industrial process heat from non-convecting solar ponds. 8-460
Solar ponds (non-convective). 9-532
Heating of the solar oriented greenhouse by means of solar air heater and solar pond and the procurement of the greenhouse humidity through special film. 10-604
Technical and economic feasibility of solar ponds. 10-618
Sede Boqer shallow pond project. 10-619

COOKERS

Performance of a flat plate collector for solar cooker. 2-094
Concave mirror solar cookers (part I). 2-095
A simple solar cooker from India. 3-159
Solar kitchens for individual use/(portable kitchens). 3-160

DRYERS

Development of flat-plate type solar energy grain dryer. 1-034
Preliminary studies of a low fuel, hop drying kiln for Himachal Pradesh, India. 1-035
Portable solar grain dryer/(thin aluminium and galvanized iron collectors for paddy drying). 3-155
A solar heated dryer for timber. 3-161
Solar heat drying of grains. 4-244
Intensifying the killing and drying process for silk cocoons with the aid of solar energy/(USSR). 4-245
Solar heated lumber dry kiln. 5-323
Solar drying potatoes/(using wind and solar energy). 5-328
Year round operation and economics of one ton/day solar paddy dryer. 5-329

Solar heating system for kiln drying lumber.	8-447
Natural and convective air drying of cassava chips.	8-456
A simple solar rice dryer: basic design theory.	8-457
Design and performance of an air collector for industrial crop dehydration/(90 °C range).	9-526
Experimental study of the influence of heat transport medium temperature and velocity on drying intensity in chamber-type solar dryers.	9-535
A solar brick-drying experiment.	9-536
Solar energy for agriculture: review of research.	10-586
Solar-heated grain dryer for the tropics.	10-606
Economical verification of a fluidized bed solar grape drier.	10-617

DESALINATION AND DISTILLATION

Desalination and solar energy/(flat-plate collecting units with economic comparison).	1-006
Solar energy collecting pond/(power and/or desalination).	1-012
Effect of closed forced circulation of a steam-air mixture in a solar desalination unit.	1-032
Solar distillation and its prospects.	2-069
Investigation of sea water desalination plants in Spain.	2-089
Study of regenerative inclined-stepped solar still.	2-090
Power generation and potable water recovery from salinous water.	3-126
Performance study of a solar still in Valencia (Spain).	3-157
Test results for a combination distilling unit/(inclined and horizontal surface).	3-158
Solar energy distillation of alcohol/(distillation column with concentrating collectors).	4-203
Strategy for the development of some low grade thermal devices/(water heaters and stills).	4-206
Solar sea water desalination for Arab countries/(Jordan).	4-240
Concerted efforts to improve the efficiency of multi-surface solar still/(lamp-black particulates).	4-241
Solar desalination/(portable stills).	4-242
Economics of solar flash evaporation.	4-284
A method for producing fresh water from sea water utilizing solar energy/(air injection of heated water).	5-315
Problems in construction and maintenance of large solar still plants.	6-395
Basic study on inclined wick-type solar stills.	6-396
Apparatus for solar distillation/(for contaminated water).	6-397
NASA Lewis Research Center photovoltaic application experiments.	9-518
Simple multiple wick solar still: analysis and performance.	9-534

GREENHOUSES

Greenhouses oriented to the sun (for more and early production).	1-036
Solar energy entrapments for early season vegetable production in cold regions.	2-093
Solar-based agricultural systems for the Middle East.	4-243
Implementation of a solar pond greenhouse heating system.	4-246
Passive energy storage in greenhouses.	4-280
Technical and economic performance of solar greenhouses using heating collection in the ground.	5-330
Greenhouses in hot climate.	6-398
Solar energy for agriculture: review of research.	10-586
Heating of the solar oriented greenhouse by means of solar air heater and solar pond and the procurement of the greenhouse humidity through special film.	10-604

OTHER SYSTEMS

Introducing solar powered solvent extraction of coconut oil in Panjang Rejo, a village in central Java, Indonesia.	2-088
Performance characteristics of solar regenerators/(for regenerating absorbent chemical solutions).	9-525
The thermodynamic cycle of the Minto solar wheel.	9-531
Fundamental study of solar brazing/(700-1000 °C).	9-533
Methanolcalcium chloride chemical heat pump for small air conditioning, heating, and storage/(single unit).	10-614
Study on solar brazing.	10-620

C. BIOCONVERSION ENERGY

GENERAL

Renewable bio-solar and microbial systems in 'Eco-Rural' development.	1-003
Photosynthesis research in the USSR.	1-039
Energy alternatives for the year 2000/(wind and biomass energy).	2-060
Biological solar energy conversion for fuels/(R&D programmes).	2-096
Biological production of liquid fuels from biomass. Summary report.	2-097
Food or fuel: new competition for world's cropland/(alcohol production).	2-114
Social and economic aspects of the introduction of gasification technology in the rural areas of the	2-116

developing countries, e.g. Tanzania.	
Natural energy sources and agriculture/(solar, wind, biomass).	3-121
Biosynthesis of enzymes by solid substrate fermentation. I. Production of CM-cellulase by *Trichoderma viride*.	3-164
Application of SGFM technology to other feedstocks.	3-165
Energy crops: a new challenge for tropical regions/(case studies conducted in Brazil).	3-166
Fuelwood and charcoal in developing countries/(economic survey).	3-167
Production of cellulase by a thermophilic *Thielavia terrestris*.	3-171
Saccharification of cellulose by acetolysis.	3-172
Self-reliant development - an IFIAS sponsored study/(systems-simulation used in India).	4-200
Solar energy: biomass/(includes listing of research organizations).	4-248
Chemicals from biomass - the U.S. prospects for the turn of the century.	4-252
Growing energy: land for biomass farms. Agricultural economic report (Final).	4-253
Continuous steady state biosynthesis of cellulase by *T. viridi* QM9414 under controlled pH.	4-256
Production of liquid fuels from plants - utilization of biomass.	4-257
Solar energy: about new energies.	5-289
Problems and opportunities for solar energy in biomass, pyrolysis and gasification.	5-290
The status of solar energy as fuel/(through biological conversion).	5-332
An overview of bio-energy projects in the United States.	5-334
Patterns of energy consumption among the urban and rural poor in developing countries.	5-360
Social forestry in India/(planting trees by all people wherever possible).	5-361
Trends in microbial technology for developing countries/(including many lists of institutions, sponsors, costs and plans).	6-399
Coconut husk-fueled pilot plant put to test/(producer gas).	6-401
Food versus fuel: competing uses for cropland.	6-412
Projected integrated farm in Nepal.	8-417
Fuelling controversy/(agriculture for food vs. energy).	8-486
Bioconversion: energy and agriculture.	9-539
Automotive fuels from cellulose materials.	9-540
Alcohols as fuels - the global picture.	9-543
Status of ethanol fuel supply from energy farming.	9-544
Compaction and densification of fuels from biomass/(history, technology and organizations involved).	9-549
Study of the effluents from the combustion of solid waste material.	9-575
An Indian village agricultural ecosystem - case study of Ungra village, part I: main observations.	10-577
An Indian village agricultural ecosystem - case study of Ungra village, part II: discussion.	10-578
A methodology for assessment of biofuel resources in developing countries.	10-621
Methane or methanol via catalytic gasification of biomass.	10-622

BIOMASS PRODUCTION AND CONVERSION

HYDROCARBON PRODUCING PLANTS

Oil plants - present and future.	2-099
Production cost analysis of *Euphorbia lathyris*. Final report.	2-101
Energy crops: a new challenge for tropical regions/(case studies conducted in Brazil).	3-166
Biological sources of energy/(*Botryococcus braunii*).	4-249
Fuel from plants/(especially *Euphorbia lathyrus*).	5-335
Higher plants as possible sources of petroleum substitutes/(potential plants; genetic engineering).	5-336
Plantations producing hydrocarbons.	5-337
Hydrocarbon fuels from plants/(algae (*Botryococcus braunii*)).	8-465
Israeli scientists focus on farming seaweed for oil/(*Dunaliella*, a salt-water seaweed).	8-466
Present situation of energy plantations.	8-467

LAND PLANTS

The amazing ipil-ipil tree/(*Leucaena leucocephala*).	2-098
Energy plantation for coromandel littoral/(*Casuarina*).	2-100
Energy crops: a new challenge for tropical regions/(case studies conducted in Brazil).	3-166
Fuelwood and charcoal in developing countries/(economic survey).	3-167
Cheap technology to produce char briquets from biomass/(from grasses, weeds, leaves and wastes).	3-168
Pithecolobium saman Benth. (rain tree) fruits as raw material for the production of ethanol.	3-169
Firewood crops/(survey).	4-251
Which alcohol fuel for Brasil, methanol or ethanol?	4-254
Social forestry in India/(planting trees by all people wherever possible).	5-361
Techno-economic felling cycles for selected energy plantation species in arid areas of western Rajasthan.	8-468
Sugar cane industry in the energy crisis.	9-547

Production of sugar cane and tropical grasses as a renewable energy source. Third quarterly report, December 1, 1978-February 28, 1979. 9-548
Arid land plants: promising new tools for economic development and basic research. 10-623
Dendro-thermal power plants vs. oil-fired power plants under Philippine conditions/(using wood from a plantation of giant ipil-ipil trees). 10-626

WATER PLANTS

Fuel from microalgae/(methane fermentation of sewage-grown micro-algae). 1-038
Potential of large-scale algal culture for biomass and lipid production in arid lands/(sewage-tolerant micro-algae). 1-042
Alcohol production from algal starch. 3-173
Solar bioconversion systems based on algal glycerol production. 4-255
A novel kind of fuel and fertilizer/(waste plants fermented to dried cakes). 4-258
Biomass from marine macroscopic plants. 5-339

RESIDUES

The economic values of wood residues as fuel/(as a function of moisture content). 1-044
Social and economic aspects of the introduction of gasification technology in the rural areas in developing countries, e.g. Tanzania. 2-116
Cheap technology to produce char briquets from biomass/(from grasses, weeds, leaves and wastes). 3-168
A novel kind of fuel and fertilizer/(waste plants fermented to dried cakes). 4-258
Coconut husk-fueled pilot plant put to test/(producer gas). 6-401
Particular problems of solid waste reclamation in developing countries. 9-541
Sugar cane industry in the energy crisis. 9-547
Utilization of waste coconut coir dust as a source of fuel/(pyrolysis). 10-624

ENERGY PLANTATIONS

Design, operation, and economics of the energy plantation as an alternate source of fuels. 1-043
Energy plantation for coromandel littoral/(Casuarina). 2-100
Growing energy: land for biomass farms. Agricultural economic report (final). 4-253
Plantations producing hydrocarbons. 5-337
Present situation of energy plantations. 8-467
Techno-economic felling cycles for selected energy plantation species in the arid areas of western Rajasthan. 8-468
Dendro-thermal power plants vs. oil-fired power plants under Philippine conditions/(using wood from a plantation of giant ipil-ipil trees). 10-626
Economic analysis of ethanol production by fermentation/(plantations of sugar cane and cassava). 10-640

ALCOHOL

The Brazilian alcohol program: a successful use of an alternative source of energy. 1-041
Biological production of liquid fuels from biomass. Summary report. 2-097
Food or fuel: new competition for world's cropland/(alcohol production). 2-114
Biosynthesis of enzymes by solid substrate fermentation. I. Production of CM-cellulase by Trichoderma viride. 3-164
Batch and continuous processing of starchy material for the production of ethanol/(from cassava). 3-170
Alcohol production from algal starch. 3-173
Solar energy distillation of alcohol/(column heated by concentrating collectors). 4-203
Biological sources of energy/(production of ethanol). 4-249
Microbial production of energy sources from biomass. 4-250
Which alcohol fuel for Brasil, methanol or ethanol? 4-254
Production of liquid fuels from plants - utilization of biomass. 4-257
Net energy analysis of alcohol production from sugarcane. 5-338
Cost control factors in the production of ethanol from sugar cane. 5-363
Trends in microbial technology for developing countries/(including many lists of institutions, sponsors, costs and plans). 6-399
Separation - a process to economically convert sugar cane biomass to fuel alcohol and high value board products. 8-463
Ethanolic fuels from renewable resources in the solar age. 8-469
Process development studies on the bioconversion of cellulose and production of ethanol. 8-470
Fuelling controversy/(agriculture for food vs. energy). 8-486
Environmental assessment of stillage control. 8-488
Automotive fuels from cellulose materials. 9-540
Alcohols as fuels - the global picture. 9-543
Status of ethanol fuel supply from energy farming. 9-544

Method and apparatus for utilizing alcohol as fuel for internal combustion engine.	9-545
Studies on the production of alcohol from cane-molasses.	9-546
Sugar cane industry in the energy crisis.	9-547
Alcoholic fermentation of raw starch without cooking by using black-koji amylase.	10-625
Economic analysis of ethanol production by fermentation/(sugar cane and cassava).	10-640

WOOD FUEL

Solid fuel cooking stoves/(survey).	1-040
The economic values of wood residues as a fuel/(as a function of moisture content).	1-044
The amazing ipil-ipil tree/(Leucaena leucocephala).	2-098
Firewood crops/(selection of the best species for a particular region and climate).	4-251
Woodfuel: a time for re-assessment/(end-use patterns and consumption).	5-340
A charcoal stove from Sri Lanka.	5-341
Improved cooking stove.	6-402
A design strategy for the implementation of stoves programmes in developing countries.	8-471
Conversion factors fuelwood:oil/(effective-heating values of wood as a function of moisture content).	9-542
Study of effluents from the combustion of solid waste material.	9-575
Methane or methanol via catalytic gasification of biomass.	10-622
Dendro-thermal power plants vs. oil-fired power plants under Philippine conditions/(using wood from a plantation of giant ipil-ipil trees).	10-626

BIOGAS PRODUCTION AND UTILIZATION

GENERAL

The community factor in community biogas plant/(India).	2-115
Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden.	3-163
Methane digesters in remote rural areas/(family-size digesters).	3-176
Microbial production of energy sources from biomass.	4-250
Guidebook on biogas development.	4-259
Methane generation by anaerobic fermentation: an annotated bibliography.	4-260
Recovery of energy by methane fermentation.	4-263
Biogas for Javanese villages: the products of digestion.	4-265
Saving Nepal's dwindling forests/(hydropower and biogas).	5-288
Biogas technology and utilization - a status report/(India).	5-342
Demonstration of anaerobic biogas digesters in developing countries. Part III. The Philippines.	5-343
Trends in microbial technology for developing countries.	6-399
Biogas technology in the Third World: a multi-disciplinary review.	6-403
Energy and economic assessment of anaerobic digesters and biofuels for rural waste management. Final report.	6-404
Projected integrated farm in Nepal.	8-417
Renewable sources of energy. Volume II. Biogas directory.	8-472
Biogas for the rural community in mainland China.	8-473
Family and community biogas plants in rural India.	8-474
Automotive fuels from cellulose materials.	9-540
Small-scale biogas processing facilities.	9-553
Economics of production of biogas from specifically-grown plant material.	9-572
A methodology for assessment of biofuel resources in developing countries.	10-621

BIOGAS PRODUCTION FROM PLANTS

Application of SGFM technology to other feedstocks/(wood and agricultural residues).	3-165
Guidebook on biogas development.	4-259
Fermentation parameters needed to improve biogas production.	9-556
Economics of production of biogas from specifically-grown plant material.	9-572

BIOGAS PRODUCTION FROM RESIDUES

Farm-scale generation of bio-gas/(swine residue).	1-047
Kinetic studies on bio-gas evolution from buffalo dung.	1-048
Anaerobic digestion-optimization of energy source from wastes.	2-102
Producing methane gas from swine manure in a pilot-sized digester.	2-104
Alternate energy sources: organic wastes as methane sources.	2-106
Application of SGFM technology to other feedstocks/(wood and agricultural residues).	3-165
Design and economy of gobar (bio) gas plant for rural use.	3-174
Methane production from cattle waste and delignified straw.	3-178
Guidebook on biogas development.	4-259
Recovery of energy by methane fermentation.	4-263

Energy conservation and production in packed-bed anaerobic bioreactor.	5-344
Methane production from animal wastes and its prospects in Japan.	5-345
Manufacture of methane from wastes.	5-348
A system for the utilization of agricultural wastes in an agro-industrial settlement - kibbutz as a model.	8-475
Enhanced energy production and water refuse for swine operation in Hawaii.	8-476
Particular problems of solid waste reclamation in developing countries.	9-541
Economic feasibility of gasification in Nigeria/(agricultural and forestry wastes).	9-550
Anaerobic fermentation of animal manure/(from biochemistry to digester design).	9-557
The role of cattle in bioconversion of solar energy to biogas and food-stuffs.	10-628
Studies on the biogas production from several animal feces.	10-629
Balanced concentrates of organic wastes enriched with selected microorganisms cultures for obtaining fuel gas based on methane.	10-631

EQUIPMENT, DIGESTER DESIGNS AND PROCESSES

Anaerobic digestion - optimization of energy source from wastes.	2-102
Anaerobic digestion of glucose with separated acid production and methane formation.	2-103
Economic and kinetic studies of the production of chemicals and farm energy by fermentation of biomass.	2-105
Design and economy of gobar (bio) gas plant for rural use.	3-174
Methane digesters in remote rural areas/(family-size digesters).	3-176
Methane fermentation of the fodder yeast stillage.	3-177
A study of hydrogen producing bacteria in anaerobic digester.	3-180
Membrane-controlled digestion: effect of ultrafiltration on anaerobic digestion of glucose.	3-181
Microbial production of energy sources from biomass/(anaerobic digestion).	4-250
Guidebook on biogas development.	4-259
Methane generation by anaerobic fermentation: an annotated bibliography.	4-260
Design analysis of small-scale anaerobic digesters in India/(5 designs).	4-261
A dome-biogas plant with separate gas holder - a system under experiment in China.	4-262
Design and operation of a farm-size anaerobic digester for swine.	4-264
Biogas for Javanese villages: the products of digestion.	4-265
Demonstration of anaerobic biogas digesters in developing countries. Part III. The Philippines.	5-343
Continuous organic waste digester and methane gas generator.	5-346
Methane on the move. A discussion of small anaerobic digesters. Final report/(portable demonstration trailer trailer in western USA).	5-347
Manufacture of methane from wastes.	5-348
Biogas technology in the Third World: a multi-disciplinary review.	6-403
Energy and economic assessment of anaerobic digesters and biofuels for rural waste management. Final report.	6-404
Basic study of methane fermentation.	6-405
A simple stirrer for a biogas plant/(for fixed-dome plants).	8-477
The construction of simple biogas digesters in the province of Szechwan, China.	9-551
Biogas in China: small-scale decentralized anaerobic digestion.	9-552
Small-scale biogas processing facilities.	9-553
Methane production by microorganisms.	9-555
Fermentation parameters needed to improve biogas production.	9-556
Anaerobic fermentation of animal manure.	9-557
Biogas in Botswana/(horizontal plug-flow digester).	10-627
Volatile fatty acids, an important state parameter for the control of the reliability and the productivities of methane anaerobic digestions.	10-630

D. WIND ENERGY

GENERAL

Feasibility study of windmills for water supply in Mara region, Tanzania.	1-049
The experiment in San Rafael, S.L.P./(sail windmill).	1-050
Energy alternatives for the year 2000.	2-060
Natural energy sources and agriculture.	3-121
Wind mills for rural India.	3-183
How one builds windmills. Calculation, construction and operation.	4-267
Wind power. Volume 1, 1970-1977 and volume 2, 1978-April 1979. (citations from the Engineering Index data base).	4-271
Conversion and storage of wind energy as nitrate fertilizer.	4-272
Economic competitiveness of windmills.	4-285
Wind power.	5-349
Wind power. (citations from the NTIS data base).	5-353
Wind power. Volume 2. 1977-April 1979 (citations from the NTIS data base).	5-354
Wind power/(increasing the efficiency of wind-power systems).	6-406

Current developments in small wind energy conversion systems/(2-40 kW; cost analysis).	6-407
Engineering considerations in implementation of novel energy concepts/(for scattered low-density communities).	9-491
Characteristics and uses of wind machines.	9-558
Wind energy in theory and practice. Basic and applications.	9-559
Economics of selected WECS dispersed applications.	9-573

DESIGNS

Development of vertical axis turbines/(National Aeronautical Lab., India).	2-107
Comparative performance measurements on a Savonius rotor with ancillary surfaces.	2-109
China taps the wind to provide power in remote areas.	3-182
A four-bladed CSC windpump from Malawi.	3-184
An oscillatory wind energy convertor.	3-185
Cost-effectiveness of the vortex-augmented wind turbine.	3-188
An evaluation of the strategy of low-cost horizontal-axis windmills.	3-195
Performance of a low cost cross-wind axis sail-wind turbine.	4-266
How one builds windmills. Calculation, construction and operation.	4-267
Design and performance of bicycle wind turbine rotors.	4-268
Wind power. Volume 1, 1970-1977 and volume 2, 1978-April 1979. (citations from the Engineering Index data base).	4-271
Wind power.	5-349
Vertical axis windmill and wind collector.	5-350
The aerodynamic design and testing of a vertical axis windmill.	5-351
Wind power. (citations from the NTIS data base).	5-353
Wind power. Volume 2. 1977-April 1979. (citations from the NTIS data base).	5-354
Cretan windmills.	6-408
Hybrid wind turbine suitable for developing regions/(Savonius type with screw type).	8-478
The Savonius rotor - performance and flow.	8-479
Characteristics and uses of wind machines.	9-558
The New Alchemy sailwing/(horizontal-axis, downwind, and sail-wing type).	9-561
Performance characteristics of sail-type horizontal axis wind rotors.	9-562
Aerodynamic studies of a straight-bladed vertical axis wind turbine.	9-563
A novel vertical axis sail rotor.	10-632
Direction-independent, concentration-augmented slow-running wind-rotor.	10-633

APPLICATIONS

Technical and economic assessment of solar powered water pumping for remote areas. Final report.	2-065
The ITDG international windpump programme: engineering design considerations used in developing a windmill system for small-scale manufacture and use in under-developed arid or semi-arid regions.	2-108
China taps the wind to provide power in remote areas.	3-182
A four bladed CSC windpump from Malawi.	3-184
Variable-stroke, wind-operated water-pumping system.	3-186
Performance matching and optimization of wind powered water pumping systems.	3-187
Wind and solar-powered reverse osmosis desalination units - description of two demonstration projects/(low-maintenance requirements for areas with poor infrastructure).	4-201
Desalting by electrodialysis using wind power.	4-269
Irrigation for very small farmers: appropriate technology or appropriate organization?	4-270
Wind power. Volume 1, 1970-1977 and volume 2, 1978-April 1979. (citations from the Engineering Index data base).	4-271
Conversion and storage of wind energy as nitrate fertilizer.	4-272
Economic competitiveness of windmills.	4-285
Vertical axis windmill and wind collector.	5-350
Free water supply from wind power.	5-352
Wind power. (citations from the NTIS data base).	5-353
Wind power. Volume 2. 1977-April 1979 (citations from the NTIS data base).	5-354
Prospects of improving wind-pump performance by load matching.	8-480
How to make fertilizer from wind, air, and water.	8-481
The New Alchemy sailwing/(horizontal-axis, downwind, and sail-wing type).	9-561
The application of wind energy systems to desalination.	9-564
Rimmed polyblade wind turbine.	10-634
The cost-effectiveness of water-pumping windmills.	10-641

E. ENERGY STORAGE

GENERAL

Review of thermal storage materials from the view point of solar energy application.	1-051
Low-temperature thermal energy storage: a state of the art survey.	2-110

Storage of low temperature heat: solar energy thermal storage. 2-111
Potentiality of glass in harnessing solar energy. 4-238
Store energy in ground. 4-277
Wind power (citations from the NTIS data base). 5-353
Wind power. Volume 2. 1977-April 1979 (citations from the NTIS data base). 5-354
Comparison between the performance of three different methods for storage and low temperature heat (solar heat) for space heating. 5-355
Heat storage in buildings: an overview. 5-357
Report of a visit to agricultural research stations using solar energy systems/(Japan). 6-369
Passive solar energy design and materials. 6-393
Heat-transmission device for solar heating systems. 8-446
Storage of heat. A survey of efforts and possibilities. 8-482
Thermal energy storage and materials for thermal energy storage. 8-483
Applications of solar energy storage systems. 8-485
Energy storage/(systems and R&D). 9-565
Comparison between the performance of three different methods for storage of low temperature heat (solarheat) for space heating/(solar pond, rock bed and salt hydrates). 9-566
Central storage for solar active space heating. 9-567
Improvement in the heat exchange performance. 9-569
Methanolcalcium chloride chemical heat pump for solar air conditioning, heating, and storage/(single unit). 10-614

SENSIBLE HEAT STORAGE

Analysis and performance of a south facing solar wall/(pipe heat exchange in blackened-glazed cement). 1-028
Fundamental studies on heat storage of solar energy. 3-189
Design aids for particulate bed systems for summer cooling. 3-192
Performance of an inexpensive constant flow solar collector/storage system in ground. 4-236
Long-term storage of solar energy in native rock. 4-276
Store energy in ground. 4-277
Sensible heat storage for solar energy applications/(eight materials). 4-278
Passive energy storage in greenhouses. 4-280
Comparison between the performance of three different methods for storage and low temperature heat (solar heat) for space heating. 5-355
Heat storage in buildings: an overview. 5-357
Charge time of a gravel-filled heat storing system. 6-409
Experimental investigation of the thermal performance of a two-compartment water storage tank. 9-570
Storing solar energy in an underground rock bed. 10-635
Lateral flow concept for rock bed systems. 10-636

LATENT HEAT, CHEMICAL AND ELECTRICAL STORAGE

Photochemical conversion and storage of solar energy. 1-052
Hybrid heat storage apparatus/(paraffin). 1-053
Organic molecular energy storage reactions. 2-112
Performance studies of a finned heat pipe latent thermal energy storage system. 3-190
Storing solar BTU: new technologies show promise but cost-effectiveness is the key/(phase-change materials reviewed). 3-191
An investigation of the thermal energy storage capacity of Glauber's salt with respect to thermal cycling. 3-193
Macro-encapsulation of heat storage phase-change materials for use in residential buildings. Final report, September 29, 1976-September 6, 1978. 3-194
Conversion and storage of wind energy as nitrate fertilizer. 4-272
Zeolites: clay silicates that offer hope of compact solar storage. 4-273
Thermal energy storage using saturated salt solutions. 4-274
Heat storage in a solar heating system using salt hydrates. 4-275
Experimental study of latent heat storage for houses. 4-279
Passive solar energy collector: Final report/(phase-change storage). 5-324
Comparison between the performance of three different methods for storage and low temperature heat (solar heat) for space heating. 5-355
Electrochemical storage of photovoltaic solar energy. 5-356
Energy storage for solar air conditioning applications utilizing a form-stable, high density polyethylene pellet bed. 5-358
Phase change thermal storage for a solar total energy system. 5-359
Investigation of heat storages with salt hydrate as storage medium based on the extra water principle. 6-410
Study of thermal energy storage based on fusion of organic materials. 6-411
Physical and chemical properties of latent heat storage materials. 8-484

Investigation of heat storages with salt hydrate as storage medium based on the extra water principle.	9-568
Solar energy and low level cyclic energy flow (20 to 100 °C) storage as chemical bond energy of compounds undergoing thermal decomposition. Final report.	10-637
Thermal energy storage using heat of solution/(saturated aqueous solutions of KNO_3, NH_4NO_3, and NH_2CONH_2).	10-638

F. SOCIO-ECONOMIC ASPECTS

SOCIAL ASPECTS

A three year review/(Shri AMM Murugappa Chettiar Research Centre, India).	1-001
Energy options: changing views from India.	1-054
Energy in rural India/(a partially closed energy eco-system description).	1-055
Food, energy and society.	2-113
Food or fuel: new competition for world's cropland/(alcohol production).	2-114
The community factor in community biogas plant/(India).	2-115
Social and economic aspects of the introduction of gasification technology in the rural areas of the developing countries, e.g. Tanzania.	2-116
Energy crops: a new challenge for tropical regions/(case studies conducted in Brazil).	3-166
Patterns of energy consumption among the urban and rural poor in developing countries.	5-360
Social forestry in India.	5-361
Biogas technology in the Third World: a multi-disciplinary review.	6-403
Energy and economic assessment of anaerobic digesters and biofuels for rural waste management. Final report.	6-404
Food versus fuel: competing uses for cropland.	6-412
Utilization of small-scale solar energy for rural development.	6-413
Energy options of the Third World.	8-416
New village use of renewable energy sources.	8-418
Renewable sources of energy. Volume II. Biogas directory.	8-472
Fuelling controversy/(agriculture for food vs. energy).	8-486
Rural energy and development: a strategic planning analysis.	9-571
Integrated energy system for non-electrified rural communities.	10-579
Social and economic aspects of the introduction of gasification technology in the rural areas in the developing countries.	10-642
Social structure and rural energy technology.	10-643

ECONOMIC ASPECTS

A three year review/(Shri AMM Murugappa Chettiar Research Centre, India).	1-001
International photovoltaic program plan. Volumes I and II.	1-019
Methane generation from human, animal and agricultural wastes.	1-045
Energy options: changing views from India.	1-054
Global aspects of sunlight as a major energy source.	2-061
Solar energy systems for continuous process/(agricultural processing).	2-081
Biological production of liquid fuels from biomass. Summary report.	2-097
Production cost analysis of *Euphorbia lathyris*. Final report.	2-101
Economic and kinetic studies of the production of chemicals and farm energy by fermentation of biomass.	2-105
Social and economic aspects of the introduction of gasification technology in the rural areas of the developing countries, e.g. Tanzania.	2-116
Energy related activities of the World Bank.	3-120
Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden.	3-163
Energy crops: a new challenge for tropical regions/(case studies conducted in Brazil).	3-166
Fuelwood and charcoal in developing countries/(economic survey).	3-167
Current costs of solar powered organic Rankine cycle engines.	3-198
Economics of small solar power plants.	3-199
Your solar energy home, including wind and methane applications.	4-202
Photovoltaic conversion of solar energy II.	4-216
Microbial production of energy sources from biomass.	4-250
Growing energy: land for biomass farms. Agricultural economic report (Final).	4-253
Desalting by electrodialysis using wind power.	4-269
Economics of adopting solar energy systems for crop irrigation: comment/(photovoltaics).	4-282
Prospects of power generation from solar plants in the northeast of Brazil.	4-283
Economics of solar flash evaporation.	4-284
Economic competitiveness of windmills.	4-285
Energy in a finite world - Volume I. Paths to a sustainable future.	5-287
Photovoltaic power systems market identification and analysis. Appendices.	5-312
Technical and economic performance of solar greenhouses using heating collection in the ground.	5-330
Woodfuel: a time for re-assessment/(end-use patterns and consumption).	5-340
Wind power.	5-349

Patterns of energy consumption among the urban and rural poor in developing countries.	5-360
Assessing solar photovoltaic energy systems for crop irrigation/(economic, technological and political).	5-362
Cost control factors in the production of ethanol from sugar cane.	5-363
Potential of renewable energies in planning the development of rural areas.	6-366
Solar water pumping.	6-388
Trends in microbial technology for developing countries.	6-399
Biogas technology in the Third World: a multi-disciplinary review.	6-403
Energy and economic assessment of anaerobic digesters and biofuels for rural waste management. Final report.	6-404
Current developments in small wind energy conversion systems.	6-407
Food versus fuel: competing uses for cropland.	6-412
Utilization of small-scale solar energy for rural development: a strategy.	6-413
Photovoltaic power systems market identification and analysis. Volume II (of 2 volumes).	6-415
Energy options for the Third World.	8-416
Renewable sources of energy. Volume II. Biogas directory.	8-472
Applications of solar energy storage systems.	8-485
Fuelling controversy/(agriculture for food vs. energy).	8-486
Energy and aid.	8-487
Solar energy utilization/(methods to weigh the costs and benefits).	9-494
Alcohols as fuels - the global picture.	9-543
Status of ethanol fuel supply from energy farming.	9-544
Wind energy in theory and practice. Basic and applications.	9-559
Rural energy and development: a strategic planning analysis.	9-571
Economics of production of biogas from specifically-grown plant material.	9-572
Economics of selected WECS dispersed applications.	9-573
Integrated energy system for non-electrified rural communities.	10-579
The future of renewable energy in developing countries.	10-581
Solar energy for agriculture: review of research.	10-586
Technical and economic feasibility of solar ponds.	10-618
Economic analysis of ethanol production by fermentation/(sugar cane and cassava).	10-640
The cost-effectiveness of water-pumping windmills.	10-641
Social and economic aspects of the introduction of gasification technology in the rural areas in the developing countries.	10-642

ENVIRONMENTAL ASPECTS

A three year review/(Shri AMM Murugappa Chettiar Research Centre, India).	1-001
Renewable bio-solar and microbial systems in 'Eco-rural' development.	1-003
Energy use in rural India.	1-055
The environmental impacts of production and use of energy, part III: renewable sources of energy.	1-056
Relevance of energy to the agricultural sector.	3-119
Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan and Sweden.	3-163
An evaluation of the strategy of low-cost horizontal-axis windmills.	3-195
Photovoltaics and environmental impact considerations/(overview of the proposed Airport Solar Photovoltaic Concentrator Project, 500 kW system).	3-196
Ecological considerations of the solar alternative.	3-197
Erosion, deforestation and loss of productivity.	4-281
Energy options for the Third World.	8-416
Renewable sources of energy. Volume II. Biogas directory.	8-472
Environmental assessment of stillage control/(from ethanol production).	8-488
Energy resources in Kenya and their environmental impacts.	9-574
Study of the effluents from the combustion of solid waste material.	9-575
Environmental effects of harvesting forests for energy.	10-639

RURAL DEVELOPMENT ASPECTS

Solar energy for rural development in the Asia and Pacific region.	1-004
Energy options: changing views from India/(debates the centralized and high-technology energy views with decentralized low-technologies for village life).	1-054
Potential of renewable energies in planning the development of rural areas.	6-366
Utilization of small-scale solar energy for rural development: a stragegy.	6-413
New village uses of renewable energy sources.	8-418
Pakistan's approach to the development of renewable energy - its resources and problems/(concept of Energy Centres: settlement with energy deficit but having raw materials for biogas production and/or sufficient wind for conversion to useful forms of energy).	8-420
Rural energy and development: a strategic planning analysis.	9-571

AUTHOR INDEX

Authors' surnames are indexed in the form appearing in the abstracted publication. Each author entry gives the publication title, issue and abstract numbers. For publications with multiple authors, an author entry is provided for each. Entries for the second and succeeding authors give references to the first author.

AARONSON, S., See DUBINSKY, Z. (1-042)
ABDELRAHMAN, M.A., A solar brick-drying experiment (9-536)
ABELES, T.P., Energy and economic assessment of anaerobic digesters and biofuels for rural waste management. Final report (6-404)
ABHAT, A., Performance studies of a finned heat pipe latent thermal energy storage system (3-190)
ABRAMOVICH, M., See DECKER, F. (5-299)
ACHILOV, B.M., Test results for a combination distilling unit (3-158)
  See AKHTAMOV, R.A. (2-090)
ACKER, F., Saving Nepal's dwindling forests (5-288)
ACOSTA, C.G., Solar energy collector device (10-608)
ADEFIA, S.S., See ONAJI, P.B. (9-550)
ADWALLADER, E.A., The application of wind energy systems to desalination (9-564)
AGADZHANOV, V.P., Technical and economic performances of solar greenhouses using heating collection in the ground (5-330)
AGARWAL, R.C., See PILLAI, P.K.C. (3-150, 5-316)
AGARWAL, R.P., See CHHABRA, A.K. (4-212)
AGNIHOTRI, O.P., See GADGIL, S.B. (10-587)
  See GUPTA, B.K. (5-295)
  See GUPTA, K.B. (1-590)
  See SHARMA, A.K. (3-128)
AHMADI, G., An oscillatory wind energy convertor (3-185)
  Performance of a low cost cross-wind-axis sail-wind turbine (4-266)
AKHMADALIEV, A., Experimental study of the influence of heat transport medium temperature and velocity on drying intensity in chamber-type solar dryers (9-535)
AKHTAMOV, R.A., Study of regenerative inclined-stepped solar still (2-090)
ALAVUTDINOV, D.N., See ALIMOV, A.K. (3-160)
ALBERY, W.J., Photogalvanic cells (9-504)
ALEXANDER, A.G., Production of sugarcane and tropical grasses as a renewable energy source. Third quarterly report, December 1, 1978-February 28, 1979 (9-548)
ALEXANDER, G., See DAWSON, F.G. (8-454)
ALFEROV, Z.I., Investigation of heterojunction photocells with an intermediate energy conversion stage at high illumination intensities (9-511)
  Photoelectric converters of concentrated solar radiation utilizing AlGaAs heterostructures (1-013)
ALICBUSAN, R.V., See ANGLO, G. (9-556)
ALIMOV, A.K., Solar kitchens for individual and collective use (3-160)
  See UMAROV, G.Y. (2-084)
ALLISON, W., See ALEXANDER, A.G. (9-548)
ALMANZA, R., Solar energy programme at the Institute of Engineering of the National University of Mexico (3-123)
ALVIM, P.D.T., Energy crops: a new challenge for tropical regions (3-166)
ALVIM, R., See ALVIM, P.D.T. (3-166)
ALVIS, R.L., Deep-well solar irrigation experiment (4-228)
ANAND, S.P., Concerted efforts to improve the efficiency of multi-surface solar still (4-241)
ANDERSON, C.I., See KAMATH, G.S. (2-075)
ANDERSON, M., Appropriate technology in Africa (10-580)
ANDERSON, R.V., Elliptical solar reflector (9-528)
ANDERSON, W.A., See RAKJANAN, K. (4-222)
  Reliability studies on MIS and transparent oxide-Si solar cells (8-437)
ANDERSSON, A., Nickel pigmented anodic aluminum oxide for selective absorption on solar energy (8-430)
ANDREEV, V.M., See ALFEROV, Z.I. (1-013)
ANGLO, G., Fermentation parameters needed to improve biogas production (9-556)
ANSON, D., Infrared radiation measurements (9-506)
  Instrumentation for solar radiation measurements (8-433)
ANTONOPOLOUS, A.A., See HORPER, J.P. (10-621)
APPELBAUM, J., Operation of DC motors powered by photovoltaic converters (5-311)
ARANETA, V.A., Continuous organic waste digester and methane gas generator (5-346)
ARIPOV, K.K., See ALFEROV, Z.I. (9-511)
ARMOLD, M.T., See ROBBINS, J.E. (3-178)
ARNOLD, J.E.M., Fuelwood and charcoal in developing countries (3-167)
ARORA, J.D., Performance of silicon solar cells in front of a water absorber (6-383)
  See VASEASHTA, A.K. (4-224)
ARORA, N.K., See SINGH, S.N. (8-439, 9-515)

ARUNGU-OLENDE, S., Energy futures in developing countries (5-286)
ARZOUMANIAN, V., See BARDOU, P. (3-124)
ASINARI DI SAN MARZANO, C.M., Volatile fatty acids, an important state parameter for the control of the reliability and the productivities of methane anaerobic digestions (10-630)
AVEZOV, R.R., Charge time of a gravel-filled heat storing system (6-409)

B

BACHMANN, A., Solar water heaters in a developing country (5-318)
BACKUS, C.E., See O'DONNELL, D.T. (3-139)
BADGER, P.C., See SHORT, T.H. (4-246)
BAGUANT, J., Electricity from the sugar cane industry in Nicaragua (8-464)
BAHADORI, M.N., Conceptual development of a solar town in Iran (9-490)
  Passive cooling systems in hot arid regions (10-615)
  Passive cooling systems in Iranian architecture (8-462)
  Performance of natural ice makers (1-031)
  Solar water pumping (6-388)
BAHAR, F., See DABIRI, A.E. (3-153)
BAHM, R.J., Calibration of solar radiation measuring instruments. Final report (4-215)
BAI, N.J., See SESHADRI, C.V. (4-200)
BAIDZHANOV, R., See BAIRAMOV, R. (4-245)
BAIRAMOV, R., Intensifying the killing and drying process for silk cocoons with the aid of solar energy (4-245)
BALACHANDRA, J., See RAO, M.R. (5-296)
BALACHANDRAN, B.N., See RAVINDRANATH, N.H. (10-577)
BALAKRISHNA, M., See RAVINDRANATH, N.H. (10-577)
BALL, G.L., See WHITAKER, R.B. (5-358)
BANDYOPADHYAY, T.K., Energy conversion through electrochemical solar cell based on CdS film photoanode (6-376)
BANNERJEE, M.K., The community factor in community biogas plant (2-115)
BANNISTER, W.S., Aerodynamic studies of a straight-bladed vertical axis wind turbine (9-563)
BARBER, E., Current costs of solar powered organic Rankine cycle engines (3-198)
BARDOU, P., Sun archi (3-124)
BARLAUD, M., Powering a submerged pump with a photovoltaic generator using a transistorized three-phase inverter (1-018)
BARNETT, A., Biogas technology in the Third World: a multi-disciplinary review (6-403)
BARNEY, W.K., Environmental assessment of stillage control (8-488)
BASU, P., See SOHA, H. (4-217)
BAUM, V.A., Use of solar radiation for creating comfortable temperature conditions in Turkmenian SSR (2-087)
BAWAGAN, P.V., Dendro-thermal power plants vs. oil-fired power plants under Philippine conditions (10-626)
BEARDSWORTH, E., See PALMEDO, P.F. (3-117)
BEAVERS, J.C., See RAMAKUMAR, R. (10-583)
BECK, S.R., Application of SGFM technology to other feedstocks (3-165)
BEDAIR, S.M., Novel concentrator photovoltaic converter system development. Final report, January 24-August 30, 1979 (2-074)
BEENACKERS, A.A.C.M., See ONAJI, P.B. (9-550)
BELL, M.A., Thermal energy storage using saturated salt solutions (4-274)
BELLANDE, R.H., Apparatus for solar distillation (6-397)
BENDT, P., See LAMERIO, G.F. (8-451)
BENEMANN, J.R., Fuel from microalgae (1-038)
BENTE, JR., P.F., An overview of bio-energy projects in the United States (5-334)
BERGKVIST, L.A., Device at heating a liquid by solar energy (2-066)
BERN, C.J., See GAYANILO, V.G. (10-606)
BERNER, T., See DUBINSKY, Z. (1-042)
BERNHART, E., The New Alchemy sailwing (9-561)
BERTHOUX, M., See BRICARD, A. (9-569)
BEST, B.R., Thermal application of solar energy (2-080)
BEURSKENS, H.J.M., Feasibility study of windmills for water supply in Mara region, Tanzania (1-049)
BHASKARAN, K.A., See SAMUEL, A.A. (4-209)
BHAT, B.K., See DOE, P.E. (1-035)
BHATTACHARYA, T.K., See JOSHI, S.P. (3-137)
BHATTACHARYYA, B.C., Design and economy of gobar (bio) gas plant for rural use (3-174)
BHAVNANI, S.H., See SUKHATME, S.P. (3-146)
BHOLAGIR, A.P., See SHARON, M. (9-505)
BIFANO, W., See RATAJCZAK, A. (9-518)
BILGEN, E., Hybrid wind turbine suitable for developing regions (8-478)
BINOT, R., See ASINARI DI SAN MARZANO, C.M. (10-630)
BIREWAR, B.R., Development of flat plate type solar energy grain dryer (1-034)
BIRNBREIER, H., See LEHNER, G. (3-125)
BLANCH, H.W., See WILKE, C.R. (8-470)
BLOSS, W.H., See LEHNER, G. (3-125)
BOER, K.W., The physics and chemistry of solar cells (3-133)
BOKIL, K.K., See RAO, K.S. (9-489)
BOL, T., See ASINARI DI SAN MARZANO, C.M. (10-630)
BOLSAITIS, P., See CHANG, Y. (4-211)
BOLTON, J.R., Photochemical conversion and storage of solar energy (4-204)
  Solar fuels (5-300)
BOMAL, R., Performance of a photovoltaic concentration module consisting of silicon solar cells with a facet cylindrical mirror COSS (10-598)
BONDARENKO, Y.I., See NASANOV, E.A. (8-446)
BOSANAC, M., See KULISIC, P. (10-638)
BOSE, S.C., Solar energy systems for continuous process (2-081)
BOUGARD, J., Solar energy and low level cyclic energy flow (20 to 100 °C) storage as chemical bond energy of compounds undergoing thermal decomposition. Final report (10-637)
BOURDEAU, L., Experimental study of latent heat storage for houses (4-279)
BRADLEY, J.O., See OCHS, T.L. (8-460)
BRAGG, G.M., Performance matching and optimization of wind powered water pumping systems (3-187)
BRAUNBECK, O., See VILLA, L.G. (8-456)
BREMONT, M., Modification of the intake-exhaust system of a MGS 2 x 1000 expansion motor in a Segal solar pump (10-603)
BRENNECKE, P., Studies into reduction of radiative heat losses of flat-plate solar collectors (9-529)

BRICARD, A., Improvement in the heat exchange performance (9-569)
BRODIN, J., Energetic efficiency of some particular types of flat plate collectors (3-152)
BROTHERS, P., See KARAKI, S. (3-132)
BROWN, K.C., Solar ponds for industrial process heat (4-232)
BROWN, L., Food versus fuel: competing uses for cropland (6-412)
BROWN, L.R., Food or fuel: new competition for the world's cropland (2-114)
BRULE, M.R., Small-scale biogas processing facilities (9-553)
BUCHBERG, H., Performance of an experimental regenerative-evaporative cooler compared with predictions (8-448)
BUHS, R., See LEHNER, G. (3-125)
BUNN, J.M., See WALTON, L.R. (10-635)
BURFORD, JR., J.L., See SCHELLENBACH, S. (5-347)
BURGESS, E.L., A novel square Fresnel lens designs for illuminating circular solar cells (3-142)
BUTTERFIELD, C.P., See HANSEN, A.C. (6-407)

C

CALDERA, E., See MARTINEZ, A.M. (10-579)
CALVIN, M., Fuel from plants (5-335)
CANALI, C., Photovoltaic conversion of solar energy II (4-216)
CANEVARI, V., See ROMEO, N. (2-076)
CANFIELD, D., See KLINE, G. (6-375)
CAPRON, P., See BOUGARD, J. (10-637)
CARDENAS, R.R., See JEFFRIES, T.W. (3-181)
CARLSON, D.E., Recent developments in amorphous silicon solar cells (3-135)
CARNEGIE, E.J., See NILES, P.W. (9-526)
CARPENTER, P., See COSTELLO, D. (1-019)
CARPER, H.J., See DEFFENBAUGH, D.M. (1-030)
CARSON, D.B., Power generation and potable water recovery from salinous water (3-126)
CARVALHO, JR., A.V., Which alcohol fuel for Brasil, methanol or ethanol? (4-254)
CASAMAJOR, A.B., Cost reductions and performance improvements for shallow solar ponds (4-247)
CASTELLANOS, A., See MARTINEZ, A.M. (10-579)
CEMBALI, F., See ZIGNANI, F. (6-380)
CHAMBOULEYRON, I., Reduction of surface recombination velocity of silicon surfaces by SnO_x films (4-223)
CHANCO, M.P., The amazing ipil-ipil tree (2-098)
CHANDRA, A., Selective coating for solar water heaters (3-149)
CHANDRA, P., Design aids for particulate bed systems for summer cooling (3-192)
CHANG, H., See BARNEY, W.K. (8-488)
CHANG, Y., A study of two binary eutectic aluminium alloys as selective absorbers for solar photothermal conversion (4-211)
CHANNESWARAPPA, A., See RAVINDRANATH, N.H. (10-577)
CHATEL, B., Some solar energy programs in the United Nations system (2-062)
  See DASILVA, E.J. (1-003)
CHEEMA, L.S., Prospects of power generation from solar plants in the northeast of Brazil (4-283)
CHEN, Y.R., See HASHIMOTO, A.G. (9-557)
CHERNE, J.M., See NILES, P.W. (9-526)
CHEVALIER, Y., Advances in theory, fabrication, and applications of bifacial solar cells (5-303)
CHHABRA, A.K., Development of selective coatings for solar photothermal absorber: electro-deposited black nickel (4-212)
CHIRANJIVI, C., Design analysis of small-scale anaerobic digesters in India (4-261)
CHOCKALINGAM, M.J., Sintered type cadmium sulphide-thallous sulphide heterojunction photovoltaic cells (3-140)
CHOPRA, K.L., See KUMAR, S.N. (3-127)
  See KAINTHLA, R.C. (9-502)
CHOUDHURY, N.K.D., See KAILA, S.K. (1-021)
CHRISTOPHER, J.C., Lateral flow concept for rock bed systems (10-636)
CIMONIS, F., Tin oxide as a spectral selective coating on enamel (4-214)
CLARK, A.F., See CASAMAJOR (4-247)
CLARK, W., See NIMMO, B. (3-144)
CLEMOT, M.G., Solar water pumping system (4-227)
COFFEY, S.G., Higher plants as possible sources of petroleum substitutes (5-336)
COHEN, A., Anaerobic digestion of glucose with separated acid production and methane formation (2-103)
COHEN, E.M., See RICE, R.E. (5-359)
COJOCARU, L., See MURGU, Z. (1-037)
COLLARES-PEREIRA, M., Approximations to the CPC - a comment on recent papers by Canning and by Shapiro (4-208)
  Preliminary results from a test array of 3X CPC collectors in a school heating application (1-022)
CONCEPCION, J.M.R., Method and apparatus for utilizing alcohol as fuel for internal combustion engine (9-545)
COOK, J., Passive designs for desert houses (9-538)
COSTELLO, D., International photovoltaic program plan. Volumes I and II (1-019)
COULSON, K.L., Solar radiation instruments (2-072)
CUEVAS, A., High efficiency bifacial back surface field solar cells (9-513)
CUOMO, J.J., Dendritic tungsten for solar thermal conversion (5-294)
CYPHER, G., See LINDSTROM, R.S. (3-130)

D

DABIRI, A.E., Experimental and theoretical performance study of solar collectors (3-153)
D'AIELLO, R.V., Epitaxial silicon growth for solar cells. Final report (3-136)
DAS, B.K., See JAIN, G.C. (2-073)
DA SILVA, G.B. Batch and continuous processing of starchy material for the production of ethanol (3-170)
DASILVA, E.J., Renewable bio-solar and microbial systems in 'eco-rural' development (1-003)
  Trends in microbial technology for developing countries (6-399)
DAVIDSON, M., Ecological considerations of the solar alternative (3-197)
DAWSON, F.G., Solar powered irrigation and the NML/Battelle solar pump (8-454)
DAY, JR., J.W., See HOPKINSON, C.S. (5-338)
DE ARMAS CASANOVA, See LLERENA, G. (9-547)
DEBAERE, L.A., See ABELES, T.P. (6-404)
DEB HOVELL, F., The role of cattle in bioconversion of solar energy to biogas and foodstuffs (10-628)

DECKER, F., Photothermal effect at TiO_2 electrodes in a photoelectro-chemical cell (5-299)
DEFFENBAUGH, D.M., Cost-effective selection of flat-plate solar collectors (1-030)
DEGEUS, A.M., Nontracking concentrating solar collector (1-008)
DEL ALAMO, J., See CUEVAS, A. (9-513)
DELYANNIS, A.A., See DELYANNIS, E.A. (2-069)
DELYANNIS, E.A., Solar distillation and its prospects (2-069)
DEMCHINSKAYA, L.A., See KOSHEL, M.I. (3-177)
DE SILVA, D., A charcoal stove from Sri Lanka (5-341)
DHILLON, G.S., See MANNAN, K.D. (4-207)
DHITAL, K., Projected integrated farm in Nepal (8-417)
DICKENSON, R.L., See MENDEL, D.A. (2-101)
DIETRICH, B., See LEHNER, G. (3-125)
DISTEFANO, T.H., See CUOMO, J.J. (5-294)
DOE, P.E., Preliminary studies of a low fuel, hop drying kiln for Himachal Pradesh, India (1-035)
DON, S.B., See SCHELLENBACH (5-347)
DOUGLASS, D.L., The selective solar absorptance of in situ-grown oxide films on metals (8-429)
DRIGGERS, J.M., See DUNCAN, C.S. (8-440)
DRUTO, N., See PRZYLUSKI, J. (9-509)
DUBEY, M., Conversion and storage of wind energy as nitrate fertilizer (4-272)
  How to make fertilizer from wind, air, and water (8-481)
DUBINSKY, Z., Potential of large-scale algal culture for biomass and lipid production in arid lands (1-042)
DUBOIS, P., Study of thermal energy storage based on fusion of organic materials (6-411)
DUBOW, J.P., See GENIS, A.P. (6-381)
DUENAS, F., See CHEVALIER, Y. (5-303)
DUFFIELD, C.P., Solar energy, water and industrial systems in arid lands: techno-ecological overview and annotated bibliography (10-585)
DUNCAN, C.S., Silicon web process development. Low cost solar array project, large area silicon sheet task. Quarterly report, October 1, 1978-December 31, 1978 (8-440)
DUNKERLEY, J., Patterns of energy consumption among the urban and rural poor in developing countries (5-360)
DUNN, P.D., Energy and the developing countries (2-059)
DURET, B., See BRICARD, A. (9-569)

E

EALASUBRAMANIAN, V., See SWARUP, G. (9-498)
EDESESS, M., See BROWN, K.C. (4-232)
EDWARDS, M., See WINGET, R.R. (8-425)
EGOROV, B.V., See ALFEROV, Z.I. (9-511)
EGUREN, J., See CUEVAS, A. (9-513)
ELLSWORTH, D.A., See ABELES, T.P. (6-404)
EMERY, K., See GENIS, A.P. (6-381)
ENGEL, T., Thin-film solar collector (6-385)
ERNANDES, L., See ALFEROV, Z.I. (9-511)
ESCOBEDO, M., See MARTINEZ, A.M. (10-579)
ESTEVE, D., The silicon concentrator photovoltaic generator Sophocles: performance and costs based on material characteristics (10-599)
EVSEEV, V.S., See GRILIKHES, V.A. (6-381, 8-453)
EWAN, J., See KAMATH, G.S. (2-077)
EXELL, R.H.B., A simple solar rice dryer: basic design theory (8-457)
EZAWA N., Characteristics of 3.5 m long heat pipe for solar collector (10-612)

F

FABRE, B., Correlations and transition regimes in a thermodynamic solar pump (9-524)
FALL, D., See BREMONT, M. (10-603)
FAN, J.C.C., See TURNER, G.W. (10-593)
FANETTI, E., High efficiency GaAs-GaAlAs solar cells for very high concentration systems (6-379)
FEDOROVA, V.D., See ALFEROV, Z.I. (9-511)
FELDMAN, JR., K.K., Development of a low-cost non-tracking heat pipe concentrating collector (10-611)
FELIX, A., See MARTINEZ, A.M. (10-579)
FELKER, P., Arid land plants: promising new tools for economic development and basic research (10-623)
FERNANDEZ, J.C., Household energy use in non-OPEC developing countries (9-492)
FERNANDEZ, J.L., See ALMANZA, R. (3-123)
FESTIN, T.F., Utilization of waste coconut coir dust as a source of fuel (10-624)
FIELD, R.L., Photovoltaic/thermoelectric refrigerator for medicine storage for developing countries (5-293)
FISCHER, J.R., Design and operation of a farm-size anaerobic digester for swine (4-264)
  Producing methane gas from swine manure in a pilot-size digester (2-104)
FLORES, C., See FANETTI, E. (6-379)
FOLEY, G., The future of renewable energy in developing countries (10-581)
FOLLEA, D., The application of solar cells (2-079)
FONTAINE, J., See GUILLEMOT, M. (4-203)
FOO, A.S., See WILLIAMS, L.A. (4-255)
FOO, E.L., See WILLIAMS, L.A. (4-255)
FOREMAN, S., See COSTELLO, D. (1-019)
FOULDS, A.W., See ALBERY, W.J. (9-504)
FRAENKEL, P.L., The ITDG international windpump programme: engineering design considerations used in developing a windpump system for small-scale manufacture and use in underdeveloped arid or semi-arid regions (2-108)
FRASER, M.D., See SZEGO, G.C. (1-043)
FREEDMAN, D., See ABELES, T.P. (6-404)
FREEMAN, C., Methane generation by anaerobic fermentation: an annotated bibliography (4-260)
FREES, H., Free water supply from wind power (5-352)
FRIES, S., See PETERSEN, G. (4-201)
FRIPIAT, J.L., See ASINARI DI SAN MARZANO, C.M. (10-630)
FUJINAKA M., Japanese style utilization of solar heat boxes (5-331)
FULFORD, D.J., A commercial approach to biogas extension in Nepal (9-554)
FULHAGE, C.D., See FISCHER, J.R. (4-264)
FURBO, S., Heat storage in a solar heating system using salt hydrates (4-275)
  Investigation of heat storages with salt hydrate as storage medium based on extra water principle (9-568)

G

GADDY, J.L., Economic and kinetic studies of the

production of chemicals and farm energy by fermentation of biomass (2-105)
GADGIL, S.B., Spectrally selective copper sulphide coatings (10-587)
GALLONI, R., See ZIGNANI, F. (6-380)
GANAPATHY, R.S., Rural energy and development: a strategic planning analysis (9-571)
GANAPINI, W., Alternate energy sources: organic wastes as methane sources (2-106)
GANDHIDASAN, P., Performance characteristics of solar regenerators (9-525)
GANESH RAJAGOPALAN, R., See GOVINDA RAJU, S.P. (8-480)
GANGULY, R., See KAILA, S.K. (1-021)
GARCIA, A., See FISCHER, J.R. (2-104)
GARCIA, F.J., n-CdS/p-ZnIn$_2$Se$_4$ thin film solar cell (9-508)
GARCIA, M., See ALEXANDER, A.G. (9-548)
GARG, H.P., Studies of a compact solar water heater (9-520)
  See PANDE, P.C. (1-051)
GARLICK, G.F.J., Forward- and reverse-bias tunneling effects in n^{+-}p silicon solar cells (4-219)
GARLITZ, J., Solar hot water heater (1-024)
GARNER, C.M., High efficiency silicon cells for luminescent solar concentrators (10-595)
GAVRILOVA, I., See KOLTUN, M.M. (4-225)
GAYANILO, V.G., Solar-heated grain dryer for tropics (10-606)
GEETHAGURU, V., See SESHADRI, C.V. (4-200)
GEHLOT, N.S., See KALLA, J.C. (8-468)
GENIS, A.P., Efficient indium tin oxide/polycrystalline silicon semiconductor-insulator-semiconductor solar cells (6-381)
GENUNG, R.K., See PIT, JR., W.W. (5-344)
GEORGESCU-ROEGEN, N., Technology assessment: the case of the direct use of solar energy (9-493)
GERISCHER, H., Solar photoelectrolysis with semiconductor electrodes (8-431)
GHATE, P.B., Irrigation for very small farmers: appropriate technology or appropriate organization? (4-270)
GHATNEKAR, S.D., A novel kind of fuel and fertilizer (4-258)
GHEZELAYAGH, H., See MEI, V. (6-394)
GHOSE, T.K., See SAHAI, V. (4-256)
GIBBS, R., Photovoltaic cells: transforming the sun's rays into electricity (8-441)
GIDASPOW, D., See MEI, V. (6-394)
GINGOLD, P.R., The cost-effectiveness of water-pumping windmills (10-641)
GITHINJI, P.M., See MARQUAND, C.J. (9-574)
GITLIN, H.M., See YANG, P.Y. (8-476)
GIVONI, B., Heat storage in buildings: an overview (5-357)
  Store energy in ground (4-277)
  See MILNE, M. (6-368)
GOEL, S.K., See JOSHI, S.P. (3-137)
GOETZBERGER, A., Fluorescent planar collector-concentrators: a review (10-600)
GOGHARI, G.H., Problems in construction and maintenance of large solar still plants (6-395)
GOHIL, H.M., See HARKARE, W.P. (4-269)
GOMKALE, S.D., See GOGHARI, G.H. (6-395)
  See HARKARE, W.P. (6-384)
GOODRICH, P.R., Farm-scale generation of bio-gas (1-047)
GORDON, N.R., Plastics honeycomb solar coverplates (6-370)
GOVINDA RAJU, S.P., Performance characteristics of sail-type horizontal axis wind rotors (9-562)
  Prospects of improving wind-pump performance by load matching (8-480)
GOVINDAN, K.P., See HARKARE, W.P. (4-269, 6-384)
GRANQVIST, C.G., See ANDERSSON, A. (8-430)
GRAVISSE, P., See SARTI, D. (10-601)
GREEN, M.A., See SINGH, R. (5-302)
GREENE, J., See HORNER, J. (4-213)
GREENWALD, A.C., See KIRKPATRICK, A.R. (9-512)
GREGOR, H.P., Ethanolic fuels from renewable resources in the solar age (8-469)
  See JEFFRIES, T.W. (3-181)
GRETHER, D., See DAVIDSON, M. (3-197)
GRILIKHES, V.A., Steam turbine installations with organic working fluids, and the outlook for using them in solar engineering (8-453)
  Vapor turbine units with organic working fluids and prospects for their use in solar power generation: survey (6-391)
GRISHUTIN, M.M., See GRILIKHES, V.A. (6-391, 8-453)
GROENEVELD, M.J., Social and economic aspects of the introduction of gasification technology in the rural areas in developing countries, e.g. Tanzania (2-116)
  Social and economical aspects of the introduction of gasification technology in the rural areas in developing countries, e.g. Tanzania (10-642)
GROLL, M., See HEINE, D. (8-484)
GROSSMAN, G., Open absorption system utilizing solar energy for air conditioning (4-231)
  See DABIRI, A.E. (3-153)
GROVER, O.P., See KUMAR, K.L. (3-183)
GRUNDMANN, E., Roll-up device to generate useful heat from solar radiation (10-607)
  See HEITLAND, H. (5-314)
GUARINI, G., See FANETTI, E. (6-379)
GUENNEC, E., See BREMONT, M. (10-603)
GUILLEMOT, M., Solar energy distillation of alcohol (4-203)
GULATI, A.P., See PANDYA, U.K. (5-319)
GUNDILER, I., See HOMHUAL, C. (6-371)
GUPTA, B.K., New approach to low cost large area selective surfaces for photothermal conversion (5-295)
  See GADGIL, S.B. (10-587)
  See SHARMA, A.K. (2-128)
GUPTA, C.L., Domestic energy consumption in India (Pondicherry region) (6-364)
GUPTA, J.P., Selective radiation properties of Indian plastics for solar heating and natural cooling of water (5-297)
GUPTA, K.B., A new approach to low cost large area selective surfaces for photochemical conversion (10-590)
GUPTA, K.C., Simple solar tracking system (1-009)
GUPTA, M.C., See GANDHIDASAN, P. (9-525)
  See SAMUEL, A.A. (4-209)
  See VENKATESH, A. (5-320, 10-605)
GUPTA, V.K., Single room heating by solar radiation (1-025)
  Solar water heaters and rural development (6-386)
GUPTA, Y.P., Economics of solar flash evaporation (4-284)
GUSTAFSON, R.J., See GOODRICH, P.R. (1-047)
GYAN, C., See KALLA, J.C. (8-468)
GYGAX, P., See WINKLER, J.P. (5-292)

H

HACKWORTH, A.J., Static solar tracker and energy converter (9-530)
HAGA K., Methane production from animal wastes and its prospects in Japan (5-345)
HAGGARD, K.L., See NILES, P.W.E. (10-616)
HAHNE, E., See LEHNER, G. (3-125)
HALE, JR., S., See PALMEDO, P.F. (3-117)
HALL, D.O., Biological solar energy conversion for fuels (2-096)
  Photosynthesis research in the USSR (1-039)
  The status of solar energy as fuel (5-332)
HALLORAN, G.M., See COFFEY, S.G. (5-336)
HAMAKAWA Y., See TAKAKURA H. (4-218)
HAMASAKI M., Study on solar brazing (10-620)
HANSEN, A.C., Current developments in small wind energy conversion systems (6-407)
HANSSON, H., See SVENSSON, P. (6-389)
HARDIE, A.D.K., A solar heated dryer for timber (3-161)
HARKARE, W.P., Solar power for electrodialysis (6-384)
  Desalting by electrodialysis using wind power (4-269)
HARPER, J.P., Assessment of Peruvian biofuel resources and alternatives (6-400)
HARRIS, M.J., See WITTENBERG, L.J. (8-458)
HART, D., Honeycomb heat trap: its application in flat plate solar collectors (2-086)
HARTWICK, P.B., See LANE, G.A. (3-194)
HASHIMOTO, A.G., Anaerobic fermentation of animal manure (9-557)
HAUER, K.L., See GOODRICH, P.R. (1-047)
HAUSER, J.R., See BEDAIR, S.M. (2-074)
HAYES, P., Social structure and rural energy technology (10-643)
HAZUM, M., See MURGU, Z. (1-037)
HEDEN, C.G., See WILLIAMS, L.A. (4-255)
HEDMAN, H., Comparison between the performance of three different methods for storage of low temperature heat (solar heat) for space heating (5-355)
HEESS, F., See HEINE, D. (8-484)
HEID, JR., W.G., See TROTTER, W.K. (10-586)
HEIFERLING, P., See COSTELLO, D. (1-019)
HEIMLICH, M.E., See DUNCAN, C.S. (8-440)
HEINE, D., Physical and chemical properties of latent heat storage materials (8-484)
HEITLAND, H., Device for producing useful heat from solar radiation (5-314)
HENRY, J.F., See SZEGO, G.C. (1-043)
HENSON, JR., W.H., See WALTON, L.R. (10-635)
HEWIG, G., See LEHNER, G. (3-125)
HIGAKI S., See HAGA K. (5-345)
HIGGINSON, B., Automotive fuels from cellulose materials (9-540)
HIGHTOWER, R.E., See PYTLINSKI, J.T. (2-085)
HILL, F.E., See DUNCAN, C.S. (8-440)
HILLEN, L.W., Hydrocarbon fuels from plants (8-465)
HIRATA, M.H., See MANSOUR, W.M. (4-268)
HIRSHBERG, G., See BERNHART, E. (9-561)
HOCHON, B., See DUBOIS, P. (6-411)
HOFMANN, P.L., See DAWSON, F.G. (8-454)
HOLDON, R.S., Fertilizers and energy from anaerobic fermentation of solid wastes (1-046)
HOMHUAL, C., Microstructural and mechanical property evaluation of zinc oxide coated solar collectors (6-371)
HOPKINS, R.H., See DUNCAN, C.S. (8-440)
HOPKINSON, JR., C.S., Net energy analysis of alcohol production from sugarcane (5-338)
HOPMANN, H., See LEHNER, G. (3-125)
HORIGOME T., See SAKUTA K. (8-445, 9-527)
  See TANAKA T. (3-189)
HORNER, J., Solar selective properties of some plated coatings (4-213)
HORPER, J.P., A methodology for assessment of biofuel resources in developing countries (10-621)
HOW, J.W., New village uses of renewable energy sources (8-418)
HOWE, E.D., Wind power (6-406)
HOWELL, D., Your solar energy home, including wind and methane applications (4-202)
HOWELL, Y., See COULSON, K.L. (2-072)
HSIEH, J.J., See TURNER, G.W. (10-593)
HUANG, C.J., See YANG, P.Y. (8-476)
HUMPHREY, A.E., Biological production of liquid fuels from biomass. Summary report (2-097)
HUNDEMANN, A.S., Solar space heating and air conditioning, volume 2, 1976-August 1977 (citations from the NTIS data base) (2-071)
  Wind power (citations from the NTIS data base). Report for 1964-Apr. 1977 (5-353)
  Wind power. Volume 1, 1970-1977 and volume 2, 1978-April 1979 (citations from the Engineering Index data base) (4-271)
  Wind power. Volume 2. 1977-April 1979 (citations from the NTIS data base). Report for 1977-April 1979 (5-354)
HUNDERI, O., See ANDERSSON, A. (8-430)
HURLEY, B., A novel vertical axis sail rotor (10-632)
HUTCHINS, M.G., Spectrally selective solar absorber coatings (9-499)
HUTSCHEMAKERS, J., See ASINARI DI SAN MARZANO, C.M. (10-630)

I

IANNOTTI, E.L., See FISCHER, J.R. (2-104, 4-264)
IGRA, O., Cost-effectiveness of the vortex-augmented wind turbine (3-188)
IIDA T., A method for producing fresh water from sea water utilizing solar energy (III) (5-315)
IKEGAMI S., See YAMAGUCHI K. (1-014)
ILAHI, A., See QADEER, M.A. (3-164)
ILES, P.A., Development of high efficiency (14%) solar cell array module. Second quarterly report, March 15-July 15, 1979 (9-514)
ILYAS, S.M., Portable solar grain dryer (3-155)
IMOMKULOV, A.I., See SHADYEV, O. (1-023)
INAL, O.T., See HOMHUAL, C. (6-371)
ISHIZAKI O., See YOSHIKAWA A. (6-378)
ITO T., Production of liquid fuels from plants - utilization of biomass (4-257)
ITO T., Report of a visit to agricultural research stations using solar energy systems (6-369)
IYENGAR, H.V.R., See NAIR, V.C. (9-546)
IYER, J.V., See GADGIL, S.B. (10-587)
IYNKARAN, K., See MUTHVEERAPPAN, V.R. (5-329, 8-450)

J

JABBAR, A., See QADEER, M.A. (3-164)
JACQUIER, A., See FABRE, B. (9-524)
JADOT, R., See BOUGARD, J. (10-637)

JAIN, B.C., See PANDYA, U.K. (5-319)
JAIN, G.C., Photovoltaics: a review (2-073)
JAFFRIN, A., See BOURDEAU, L. (4-279)
JAGADISH, B.S., Economics of small solar power plants (3-199)
JAMES, L.W., Novel solar cell concentrator photovoltaic converter system. Final report, April 1979 (6-382)
JAYADEV. T.S., See BROWN, K.C. (4-232)
JAYET, P.A., Bioconversion: energy and agriculture (9-539)
JAYPRAKASH, L., See BANNERJEE, M.K. (2-115)
JEFFRIES, T.W., Membrane-controlled digestion: effect of ultrafiltration on anaerobic digestion of glucose (3-181)
  See GREGOR, H.P. (8-469)
JENKINS, G.H., See WHITAKER, R.B. (5-358)
JENSEN, J., Energy storage (9-565)
JI BIAN, China taps the wind to provide power in remote areas (3-182)
JOHANNES, H., Cheap technology to produce char briquets from biomass (3-168)
JOHNSON, D.W., See VAN HOOK, R.I. (10-639)
JONES, C.N., The Savonius rotor - performance and flow (8-479)
JONGMA, J., See ARNOLD, J.E.M. (3-167)
JOSE, W.I., See FESTIN, T.F. (10-624)
JOSEPH, S., A design strategy for the implementation of stoves programmes in developing countries (8-471)
JOSHI, S.P., Development of silicon solar cells for concentrated sunlight (3-137)
JUAREZ, M., See BEST, B.R. (2-080)
JULIAO, F., See DECKER, F. (5-299)
JUSTI, E., See BRENNECKE, P. (9-529)

K

KACHARE, A.H., See GARLICK, G.F.J. (4-219)
KAETSU I., See OKUBO H. (4-210)
KAILA, S.K., Pipe type solar water heating (1-021)
KAINE, M., See BILGEN, E. (8-478)
KAINTHLA, R.C., Solution growth of CdSe and PbSe films (9-502)
KAKABAYEV, A., See BAUM, V.A. (2-087)
KAKHAROV, S., See ACHILOV, B.M. (3-158)
  See AKHTAMOV, R.A. (2-090)
KALLA, J.C., Techno-economic felling cycles for selected energy plantation species in the arid areas of western Rajasthan (8-468)
KAM, K., See KLINE, G. (6-375)
KAMAT, P.V., Temperature effects in photoelectrochemical cells (2-064)
  See MOORTHY, P.N. (3-131)
KAMATH, G.S., GaAs-GaAlAs solar cells (2-075)
  Large-area high-efficiency (AlGa)As-GaAs solar cells (2-077)
KAMATH, S., High efficiency GaAs solar cell development (8-435)
KAMILOV, O.S., See AKHTAMOV, R.A. (2-090)
KAMIMOTO M., Thermal energy storage and materials for thermal energy storage (8-483)
KANAKI, M.T., Cretan windmills (6-408)
KANDLIKAR, S.G., See SUKHATME, S.P. (3-146)
KANE, V.R., Low cost solar water heating for large scale applications (4-230)
KARAKI, S., Experimental investigation of an inexpensive sky temperature measuring device (3-132)
KARKHANAVALA, M.D., See KAMAT, P.V.(2-064)
  See MOORTHY, P.N. (3-131)
KASAI H., See YOSHIKAWA A. (6-378)
KATZMAN, M.T., See MATLIN, R.W. (5-362)
KAUFFMAN, K.W., See LORSCH, H.G. (9-567)
KAUFMAN, H., Biogas in China: small scale-decentralized anaerobic digestion (9-552)
KAUSHIK, S.C., See SODHA, M.S. (4-236)
KAWAI A., Present situation of energy plantations (8-467)
KAY, T., Solar collector panel and refrigeration system operated thereby (4-229)
KEDIA, Y.P., Strategy for the development of some low grade thermal devices (4-206)
KEELING, M.C., See PASTIRIK, E.M. (1-010)
KELLER, B.N., See KOSHEL, M.I. (3-177)
KELLY, F.H.C., Cost control factors in the production of ethanol from sugar cane (5-363)
KERSHAVRAJ, N., See SESHADRI, C.V. (4-200)
KHEMTHONG, S., See ILES, P.A. (9-514)
KHOURI, R.G., Harnessing the Mideast sun (3-122)
KILKIS, B., Application of solar flat plate collector in Turkey (2-083)
  Economical verification of a fluidized bed solar grape drier (10-617)
KIM, H.U., See KWON, I.K. (10-629)
KIM, J.K., See ANDERSON, W.A. (8-437)
  Photovoltaic properties of thin film Cu_2Se-CdSe heterojunctions (10-596)
KIRKPATRICK, A.R., Silicon solar cells by high-speed low-temperature processing (9-512)
KISHORE, K., See RASTOGI, R.P. (1-048)
KLINE, G., Efficient and stable photoelectrochemical cells constructed with WSe_2 and $MoSe_2$ photoanodes (6-375)
KLINE, G.L., See GAYANILO, V.G. (10-606)
KLYSHCHAEVA, O., Preliminary tests of solar unit for reduction of heat content and evaporative cooling of air (8-449)
KNECHTLI, R.C., See KAMATH, G.S. (2-077)
KOBA Y., See UEDA, S. (10-625)
KOBAYASHI G., Solar water heater designed mainly aiming at the economical efficiency of installation cost (6-387)
KOLTUN, M.M., Optimization of electrical and optical characteristics of silicon photoelements designed for photothermal converters of concentrated solar radiation (4-225)
KONAGAI M., See SUZUKI T. (8-434)
KONDO T., See USHIYAMA I. (6-405)
KOONTZ, R., See COSTELLO, D. (10-019)
KOROL'KOV, V.I., See ALFEROV, Z.I. (1-013)
KORR, A.L., Apparatus for the collection and conversion of solar energy (10-609)
KORYAGIN, N.I., Production and use of rolled-welded panels of aluminum alloys for solar water heaters of hot water supply and cooling systems (5-313)
KOSARI, A., See BAHADORI, M.N. (1-031)
KOSHEL, M.I., Methane fermentation of fodder yeast stillage (3-177)
KOTNALA, R.K., See SINGH, S.N. (8-439)
KOTT, A.C., See LANE, G.A. (3-194)
KOWALEWSKA, J., See WETTERMARK, G. (2-111)
KRAWIEC, S., Economics of selected WECS dispersed applications (9-573)
KROLL, R., See HEITLAND, H. (5-314)
  See GRUNDMANN, E. (10-607)

KRUPNICK, A.C., See ROBERTS, M.L. (10-589)
KUDISH, A.I., Compact shallow solar pond hot water heater (1-020)
  Sede Boqer shallow pond project (10-619)
  Sede Boqer, shallow solar ponds project (5-327)
KUEHN, I., See WILLIAMS, L.A. (4-255)
KULISIC, P., Thermal energy storage using heat of solution (10-638)
KUMAR, A., Utilization of hollow slabs in heating and cooling of buildings (3-148)
  See SODHA, M.S. (9-534)
  See TIWARI, G.N. (1-028)
KUMAR, K.L., Wind mills for rural India (3-183)
KUMAR, S.N., Low cost electroless nickel black coatings for photothermal conversion (3-127)
KURIHARA J., See TANAKA S. (9-521)
KURUP, G.T., See ILYAS, S.M. (3-155)
KWON, I.K., Studies on the biogas production from several animal feces (10-629)

L

LACHER, S.L., See ROBBINS, J.E. (3-178)
LAHRI, R., See JOSHI, S.P. (3-137)
LALLI, V.R., Photovoltaic power system reliability considerations (9-517)
LAMERIO, G.F., The GFL method for sizing solar energy space and water heating systems (8-451)
LAMORTE, M.F., Cascade solar cells (3-138)
  See BEDAIR, S.M. (2-074)
LANE, G.A., Macro-encapsulation of heat storage phase-change materials for use in residential buildings. Final report, September 29, 1976-September 6, 1978 (3-194)
LAPIN, E.E., Economic competitiveness of windmills (4-285)
LARINOV, V.R., See ALFEROV, Z.I. (9-511)
LARSON, V., See GOODRICH, P.R. (1-047)
LASSNER, N., See BUCHBERG, H. (8-448)
LAURIE, C.K., Separation - a process to economically convert sugar cane biomass to fuel alcohol and high value board products (8-463)
LAUVRAYA, H., Process to reduce the manufacturing cost of monocrystalline solar cells (8-438)
LAVAN, Z., See MEI, V. (6-394)
LAWAND, T.A., Potential of renewable energies in planning the development of rural areas (6-366)
LAWN, J., Storing solar BTU: new technologies show promise but cost-effectiveness is the key (3-191)
LE POULL, F., See SARTI, D. (10-601)
LEBOURG, R., See GUILLEMOT, M. (4-203)
LEE, J.C., See LIN, R.J.H. (9-501)
LEE, K., Encyclopedia of energy-efficient building design: 391 practical case studies. Volumes I and II (6-367)
LEHNER, G., Solar technology: fundamentals, applications, and future outlook (3-125)
LENTH, C.S., See RUDOLPH, L.I. (1-054)
LESINO, G., See MANQUSSI, J. (5-325)
LEUNG, C.T., Performance test of a non-parabolic asymmetrical solar concentrator (4-234)
LIANG SHAOXIAN, Silicon solar cell power supply with auto-tracker (5-309)
LIAO DUOQUN, See LIU KEXIN (3-180)
LIN, R.J.H., Low-cost solar antireflection coatings. Annual report, 24 July 1978-24 September 1979 (9-501)
  Low-tempterature solar coatings (8-427)
LIN, S., Experimental investigation of the thermal performance of a two-compartment water storage tank (9-570)
LIN, Z.I.H., Technical and economic feasibility of solar ponds (10-618)
LINDMAYER, J., Development of an improved high efficiency thin solar cell. Quarterly report (5-306)
LINDSTROM, R.S., Selective surfaces for copper solar absorbers (3-130)
LING, K.S., See ILES, P.A. (9-514)
LITTLER, R.D., See JONES, C.N. (8-479)
LIU KEXIN, A study of hydrogen producing bacteria in anaerobic digester (3-180)
LLERENA, G., Sugar cane industry in the energy crisis (9-547)
LOBO, P.C., See CHEEMA, L.S. (4-283)
LOF, G.O.F., Heating of building with solar energy (1-027)
LOPEZ GUZMAN, See LLERENA, G. (9-547)
LORSCH, H.G., Central storage for solar active space heating (9-567)
LUQUE, A., See CUEVAS, A. (9-513)
LU TI, China votes for sun (8-424)
LU WEI DE, Solar energy research and applications in China (1-005)

M

MA YI, Biogas for the rural community in mainland China (9-473)
MACGARRY, B., Biogas in Botswana (10-627)
MADON, G., See BREMONT, M. (10-603)
MAGHSOOD, J., Solar energy entrapments for early season vegetable production in cold regions (2-093)
MAHABALA, R.A., See HARKARE, W.P. (6-384)
MAHANTY, P., See SEN, P. (1-015)
MAJEETHIA, K.M., See HARKARE, W.P. (4-269)
MAJUMDAR, M.N., See BANDYOPADHYAY, T.K. (6-376)
MALEVSKII, Y.N., See KORYAGIN, N.I. (5-313)
MALHOTRA, L.K., See KUMAR, S.N. (3-127)
MALIK, M.A.S., See SODHA, M.S. (4-236)
MALYKNINA, I., See KORYAGIN, N.I. (5-313)
MANASSE, F.K., Comparison of costs for solar electric sources with diesel generators in remote locations (6-414)
MANDUJANO, M., See MARTINEZ, A.M. (10-579)
MANGUSSI, J., The use of sodium sulfate in solar ponds (5-325)
MANI, J.V.S., See SAKSENA, R.K. (5-317)
MANN, L.K., See VAN HOOK, R.I. (10-639)
MANNAN, K.D., Natural thermal environmental control of houses in northern India (4-207)
MANOHARAN, R., See SESHADRI, C.V. (4-200)
MANSER, B.L., See JONES, C.N. (8-479)
MANSOUR, W.M., Design and performance of bicycle wind turbine rotors (4-268)
MANZO, J.P., Applications of solar energy storage systems (8-485)
MARCHAIM, U., See ROUSSEAR, I. (8-475)
MARCHI, D.L., See BURGESS, E.L. (3-142)
MARIANI, E., See HARPER, J.P. (6-400)
MARION, R.H., Use of thin glass reflectors for solar concentrators (9-500)
MARKS, S., An investigation of the thermal energy storage capacity of Glauber's salt with respect to thermal cycling (3-193)

MARQUAND, C.J., Energy resources in Kenya and their environmental impacts (9-574)
MARTINEZ, A.M., Integrated energy system for non-electrified rural communities (10-579)
MARTINEZ-LOZANO, J.A., See RIERA, J. (3-157)
MARTZ, J., See RATAJCZAK, A. (9-518)
MASSELOT, C., See BARLAUD, M. (1-018)
MASSOUDI, M.S., Study of the effluents from the combustion of solid waste material (9-575)
MASTELIC, J., See KULISIC, P. (10-638)
MASTERS, R.M., Inexpensive, portable, integrating solar energy meter (10-592)
MATHUR, P.C., See ARORA, J.D. (6-383)
  See VASEASHTA, A.K. (4-224)
MATHUR, S.S., See GUPTA, B.K. (5-295)
  See GUPTA, K.B. (10-590)
  See SHARMA, A.K. (3-128)
MATLIN, R.W., Assessing solar photovoltaic energy systems for crop irrigation (5-362)
MATSUMOTO H., See YAMAGUCHI K. (1-014)
MAUREL, A., See PLOYART, R. (1-006)
MAYER, B.E., See BEST, B.R. (2-080)
MAZUMDER, B., Potentiality of glass in harnessing solar energy (4-238)
MCCORMICK, P.O., Solar heating system for kiln drying lumber (8-447)
MCELROY, R.G., See TROTTER, W.K. (10-586)
MCHUGH, J.P., See DUNCAN, C.S. (8-440)
MCNEILL, S.G., See WALTON, L.R. (10-635)
MEADOR, N.F., See FISCHER, J.R. (4-264)
MEI, V., Development of a solar desiccant dehumidifier II (6-394)
MELCHIOR, J.L., See ASINARI DI SAN MARZANO, C.M. (10-630)
MENARY, R.C., See DOE, P.E. (1-035)
MENDEL, D.A., Production cost analysis of *Euphorbia lathyris*. Final report (2-101)
MENDYK, J., See PRZYLUSKI, J. (9-509)
MEREDITH, D.B., The desiccant/rock bed method of solar cooling with air collectors (5-321)
MERLE, D., See FABRE, B. (9-524)
MERRIAM, M.F., Characteristics and uses of wind machines (9-558)
MERRIAM, R.L., See LINDSTROM, R.S. (3-130)
MERRIFIELD, D.V., See ROBERTSON, S.J. (5-323)
MEZOFF, C., Residential solar designs using pyramidal optics solar systems (4-237)
MICHEL, J., Single crystal silicon photocells for terrestrial use - state of the art and perspectives on the future (4-221)
MICHELS, T., Solar energy utilization (9-494)
MILLER, A.R., See WINGET, R.R. (8-425)
MILNE, M., Architectural design based on climate (6-368)
MILON, J.W., Economics of adopting solar energy systems for crop irrigation: comment (4-282)
MIMAKI M., See WATANABE K. (6-396)
MINNUCCI, J.A., See KIRKPATRICK, A.R. (9-512)
MIRAKHUR, R.K., See GUPTA, K.C. (1-009)
MISAWA S., See YOSHIDA S. (10-588)
MISHRA, C.B., Performance study of air-heated packed-bed solar-energy collectors (9-522)
MISRA, H., See SEN, P. (1-015)
MITCHELL, D.H., Methane or methanol via catalytic gasification of biomass (10-622)
MITO S., See TSUJI T. (5-308)
MITRA, A., See POTDAR, H.S. (6-373)
MITRA, C.R., See KEDIA, Y.P. (4-206)
MITSUI K., See YOSHIDA S. (10-594)
MOACANIN, J., See SARBOLOUKI, M.N. (4-252)
MOHN, J., See PETERSEN, G. (2-201)
MOISAN, A., See BOURDEAU, L. (4-279)
MOLLY, J.P., Wind energy in theory and practice. Basic and applications (9-559)
MONACO, L.C., The Brazilian alcohol program: a successful use of an alternative source of energy (1-041)
MONTMAYEUR, J.D., Recent heat pipe applications at the CEN, Grenoble, France (10-613)
MONTOYA, J., See CHAMBOULEYRON, I. (4-223)
MOON, R.L., See JAMES, L.W. (6-382)
MOORTHY, P.N., Direct photoelectrochemical conversion and storage of solar energy (3-131)
  See KAMAT, P.V. (2-064)
MORAGUES, J.A., Photothermal conversion of solar energy into electricity (3-143)
MORALES, E.C., See SIMPSON, M.H. (5-343)
MORAWETZ, B.I., See MORAWETZ, E. (1-053)
MORAWETZ, E., Hybrid heat storage apparatus (1-053)
MORRISON, G.L., Passive energy storage in greenhouses (4-280)
MUCHIRI, G., Rural energy needs and alternative sources (10-582)
MUDGE, L.K., See MITCHELL, D.H. (10-622)
MUKHOPADHYAYA, K., See SOHA, H. (4-217)
MULAS, P., See MARTINEZ, A.M. (10-579)
MULLER, A., See PETERSEN, G. (4-201)
MUNOZ, F., See ALMANZA, R. (3-123)
MURADOV, Z., See BAIRAMOV, R. (4-245)
MURGU, D., See MURGU, Z. (1-037)
MURGU, Z., Heat pipes for sun energy conversion (1-037)
MURO, S., Investigation on sea water desalination plants in Spain (2-089)
MURR, L.E., See HOMHUAL, C. (6-371)
MURTHY, A.S.N., Photochemical energy conversion studies in systems containing methylene blue (1-011)
MURTHY, V.S., See NAND, K. (3-169)
MUTHVEERAPPAN, V.R., Cheap roof type solar air heaters for industries (8-450)
  Year round operation and economics of one ton/day solar paddy dryer (5-329)

N

NAGAR, V.K., Structured coatings for solar energy collectors (8-428)
NAGARAJA RAO, K., See CHOCKALINGAM, M.J. (3-140)
NAGARAJU, S.M., See RAVINDRANATH, N.H. (10-577)
NAGASUBRAMANIAN, G., Electrochemical photovoltaic cells for solar energy conversion (5-298)
NAHAR, N.M., Measurement of flat-plate collector heat loss coefficients (9-523)
NAIR, V.C., Studies on the production of alcohol from cane-molasses (9-546)
NAKAGAWA K., Solar heat drying of grains (4-244)
NAKAYAMA N., See YAMAGUCHI K. (1-014)
NAKOS, J.C., See BAHM, R.J. (4-215)
NAND, K., *Pithecolobium saman* Benth. (Rain tree) fruits as raw material for the production of ethanol (3-169)
NASBY, R.D., See GARNER, C.M. (10-595)
NASONOV, E.A., Heat-transmission device for solar heating systems (8-446)
NATARAJAN, P., See TAMILARASAN, R. (8-432)

NATHANS, R., See PALMEDO, P.F. (3-117)
NATU, G.L., See GOGHARI, G.H. (6-395)
NAVEAU, H., See ASINARI DI SAN MARZANO, C.M. (10-630)
NAYAR, M.G., See CHHABRA, A.K. (4-212)
NAZAROV, K., See ALIMOV, A.K. (3-160)
NEWTON, E.H., See LINDSTROM, R.S. (3-130)
NGUYEN, D.V., Comparative performance measurements on a Savonius rotor with ancillary surfaces (2-109)
NILES, P.W., Design and performance of an air collector for industrial crop dehydration (9-526)
NILES, P.W.E., Passive solar handbook (10-616)
NIMMO, B., Analytical and experimental study of pumped solar water heaters (3-144)
NISHIMAKI M., See YOSHIKAWA A. (6-378)
NISHIMURA H., Oil plants - present and future (2-099)
  Plantations producing hydrocarbons (5-337)
NISHIYAMA S., See OKUBO H. (4-210)
NITTA Y., See YOSHINO A. (10-640)
NIYAZOV, S.K., See AVEZOV, R.R. (6-409)
NOREEN, D.L., See FELDMAN, K.K. (10-611)
NOROV, E., See ACHILOV, B.M. (3-158)
NORTH, W.J., Biomass from marine macroscopic plants (5-339)
NOWACKI, J.E., See HEDMAN, H. (5-355)
NYLINDER, M., Conversion factors fuelwood: oil (9-542)
NYNS, E.J., See ASINARI DI SAN MARZANO, C.M. (10-630)

O

O'DONNELL, D.T., Performance of silicon and gallium arsenide concentration cells (3-139)
O'DONNELL, P., See RATAJCZAK, A. (9-518)
O'GALLAGHER, J., See COLLARES-PEREIRA, M. (1-022, 4-208)
  See RABL, A. (2-070, 4-233)
O'KEEFE, P., See SHAKOW, D. (10-576)
OCHS, T.L., Low temperature industrial process heat from non-convecting solar ponds (8-460)
ODA T., See YOSHIDA S. (10-594)
OFFENHARTZ, P.O., Methanolcalcium chloride chemical heat pump for solar air conditioning, heating, and storage (10-614)
OHGAKI, M., See TATSUMI T. (3-173)
OKUBO H., Manufacture of Fresnel lens by radiation cast polymerization (4-210)
OLALDE, Q.G., See BEST, B.R. (2-080)
OLAN, S., See ILES, P.A. (9-514)
OMSTEAD, D.R., See JEFFRIES, T.W. (3-181)
ONAJI, P.B., Economic feasibility of gasification in Nigeria (9-550)
ONG, K.S., Comparative performance testing of flat-plate solar water heaters (10-610)
ONO H., Recovery of energy by methane fermentation (4-263)
OPENSHAW, K., Woodfuel: a time for re-assessment (5-340)
OVECHKIN, N.F., See ALIMOV, A.K. (3-160)
  See UMAROV, G.Y. (2-084)

P

PAL, R.S., See CHANDRA, P. (3-192)
PALMEDO, P.F., Energy needs, uses and resources in developing countries (3-117)
PANDE, P.C., Review of thermal storage materials from the view point of solar energy application (1-051)
PANDYA, D.K., See KAINTHLA, R.C. (9-502)
PANDYA, U.K., Experiences with a large size solar hot water system (5-319)
PANT, M.M., Social forestry in India (5-361)
PARASCHIVOIU, I., See BILGEN, E. (8-478)
PARKINSON, B.A., See KLINE, G. (6-375)
PARSONS, R.E., See CASAMAJOR, A.B. (4-247)
PASTIRIK, E.M., Low cost, durable anti-reflective film for solar collectors (1-010)
PAUWELS, H., See VANHOUTTE, G. (5-307)
PAVASKAR, N., See POTDAR, H.S. (6-373)
PEARCE, J., See NIMMO, B. (3-144)
PEDULLI, L., See ZIGNANI, F. (6-380)
PELLEGRINI, G., Experimental methods for the preparation of selectively absorbing textured surfaces for photothermal solar conversion (2-068)
PELLICORI, S.F., Wind band wide angle reflection-reducing coatings for silicon cells (4-226)
PERELMAN, L., See COSTELLO, D. (1-019)
PEREZ, I., See ASINARI DI SAN MARZANO, C.M. (10-630)
PETERSEN, G., Wind and solar-powered reverse osmosis desalination units - description of two demonstration projects (4-201)
PETTIT, R.B., See DOUGLASS, D.L. (8-429)
PILATOWSKY, F.I., See BEST, B.R. (2-080)
PILLAI, P.K.C., Performance evaluation of spiral solar collector (5-316)
  Techniques of selected coating (2-067)
  Tubular solar collector (3-150)
PIMENTEL, D., Food, energy and society (2-113)
  Relevance of energy to the agricultural sector (3-119)
  See VERGARA, W. (3-163)
PIMENTEL, M., See PIMENTEL, D. (2-113, 3-119)
PINDER, K.L., See WILKINS, E.S. (2-092)
PIT, JR., W.W., Energy conservation and production in a packed-bed anaerobic bioreactor (5-344)
PLOYART, R., Desalination and solar energy (1-006)
PLUMPTRE, R.A., See HARDIE, A.D.K. (3-161)
POCARD, M.P., Turbines and turbogenerators for solar power plants with thermodynamic cycles (1-026)
POHL, J.G., See NILES, P.W. (9-526)
PORTER, J.H., See FISCHER, J.R. (2-104)
POSNER, O., See COSTELLO, D. (1-019)
POTDAR, H.S., Solar selective copper-black layers by an anodic oxidation process (6-373)
PRADHANANGA, R.R., See SHARON, M. (9-505)
PRAKASH, B., Utilization of small-scale solar energy for rural development: a strategy (6-413)
PRASAD, A., See SINGH, S.N. (9-515)
PRASAD, B.M., See SHARON, M. (9-505)
PRIB, B., See KULISIC, P. (10-638)
PRIOR, R.L., See HASHIMOTO, A.G. (9-557)
PRITCHARD, C., Engineering considerations in implementation of novel energy concepts (9-491)
PROBERT, S.D., See KANAKI, M.T. (6-408)
PRYOR, C.A., Erosion deforestation and the loss of productivity (4-281)
PRZYLUSKI, J., Application of electrochemical methods in $Ga_{1-x}Al_xAs$/GaAs solar cell fabrication (9-509)
PUGA, N., See MARTINEZ, A.M. (10-579)
PULFREY, D.L., MIS solar cells: a review (3-134)
PURI, J.S., See KAILA, S.K. (1-021)
PURI, V.M., Status and prospects of local solar

heating and cooling systems (1-007)
PYLE, L., See BARNETT, A. (6-403)
PYTLINSKI, J.T., Solar energy: past and present developments (2-063)
  Use of a honeycomb as solar radiation absorber and heat exchange in an air-type solar collector (2-085)

Q

QADEER, M.A., Biosynthesis of enzymes by solid substrate fermentation. I. Production of CM-cellulase by *Trichoderma viride* (3-164)
QUADER, A.K.M.A., Experimental study into cooling effect by nocturnal radiation to outer space for possible applications in rural areas (1-033)
QURESHI, M.S., Pakistan's approach to the development of renewable energy - its resources and problems (8-420)

R

RABINOVICH, L.I., See SEKITKURBANOV, S. (1-032)
RABL, A., Design and test of non-evacuated solar collectors with compound parabolic concentrators (2-070, 4-233)
  See COLLARES-PEREIRA, M. (1-022, 4-208)
RAFINEJAD, D., Design of a 150 kW solar-powered irrigation facility (8-455)
RAGOT, P., See BOMAL, R. (10-598)
RAIA, G., See SESHADRI, C.V. (4-200)
RAJESWARAN, G., See RAJKANAN, K. (4-222)
RAJKANAN, K., Loss mechanisms analysis in single-crystal and polycrystalline silicon MIS solar cells to produce 13% efficiency (4-222)
RAJKANAN, K., See SINGH, R. (5-302)
RAJPAKSE, S., A simple stirrer for a biogas plant (8-477)
RAJUPUT, R.K., Performance of a flat plate collector for solar cooker (2-094)
RAMAKUMAR, R., Perspective on developing country solar energy applications (10-583)
RAMOS DE FARIAS, R., Balanced concentrates of organic wastes enriched with selected microorganisms cultures for obtaining fuel gas based on methane (10-631)
RANGARAJAN, N., See CHOCKALINGAM, M.J. (3-140)
RANI, U., See GARG, H.P. (9-520)
RAO, K.N., See NAGARAJA RAO, K.
RAO, K.S., Integrated rural energy plan: a case study of a typical village in Kutch district of Gujarat state (9-489)
RAO, K.U., See GUPTA, C.L. (6-364)
RAO, M.R., Spectral selective properties of black chrome and nickel electrodeposited coatings for solar absorber (5-296)
RAO, M.V.N., See GUPTA, J.P. (5-297)
RASTOGI, R.P., Kinetic studies on bio-gas evolution from buffalo dung (1-048)
RATAJCZAK, A., NASA Lewis Research Center photovoltaic application experiments (9-518)
RAVINDRANATH, N.H., An Indian village agricultural ecosystem - case study of Ungra village, Part I: main observations (10-577)
REDDY, A.K.N., An Indian village agricultural ecosystem - case study of Ungra village, Part II: discussion (10-578)
  Energy options for the Third World (8-416)
  See RAVINDRANATH, N.H. (10-577)
REDDY, K.S., See MURTHY, A.S.N. (1-011)
REED, T., Problems and opportunities for solar energy in biomass, pyrolysis, and gasification (5-290)
REICHEL, R.S., Windpower programmes in Tanzania (9-560)
REINMUTH, F., See LEHNER, G. (3-125)
RESTREPO, I., See MARTINEZ, A.M. (10-579)
REVELLE, R., Energy dilemmas in Asia: the needs for research and development (2-058)
  Energy use in rural India (1-055)
RIAZ, M., Long-term storage of solar energy in native rock (4-276)
RICE, R.E., Phase change thermal storage for a solar total energy system (5-359)
RICHMAN, D., See D'AIELLO, R.V. (3-136)
RICHMOND, B., See STEWARD, J. (4-265)
RIERA, J., Performance study of a solar still in Valencia (Spain) (3-157)
RIGHELATO, R.C., Microbial production of energy sources from biomass (4-250)
RILEY, V.J., Energy related activities of the World Bank (3-120)
ROA, G., See VILLA, L.G. (8-456)
ROBB, S.P., See O'DONNELL, D.T. (3-139)
ROBBINS, F.V., Computer modeling of a ventilated Trombe wall - with actual performance results (3-156)
ROBBINS, J.E., Methane production from cattle waste and delignified straw (3-178)
ROBERTS, JR., C.C., Non-tracking moderately focusing heat pipe solar collector (3-151)
ROBERTS, M.L., Aluminium or copper substrate panel for selective absorption of solar energy (10-598)
ROBERTSON, E.E., Compaction and densification of fuels from biomass (9-549)
ROBERTSON, S.J., Solar heated lumber dry kiln (5-323)
ROBERTUS, R.J., See MITCHELL, D.H. (10-622)
ROBISON, H.I., Liquid desiccant solar air conditioner and energy storage system (6-390)
ROBINSON, P.H., See D'AIELLO, R.V. (3-136)
ROGERS, P.L., Biological sources of energy (4-249)
ROLLER, W.L., See SHORT, T.H. (4-246)
ROLZ, C., Particular problems of solid waste reclamation in developing countries (9-541)
ROMAK, R.K., Sensible heat storage for solar energy applications (4-278)
ROMEO, N., CuGa$_x$In$_{1-x}$Se$_2$ thin films for solar cells prepared by flash-evaporation (2-076)
ROSSOW, H.E., See LANE, G.A. (3-136)
ROUSSEAR, I., A system for the utilization of agricultural wastes in an agro-industrial settlement - kibbutz as a model (8-475)
ROY, A., See KUDISH, A.I. (5-327)
ROY, R., Family and community biogas plants in rural India (8-474)
ROY, R.N., See SESHADRI, C.V. (4-200)
RUDOLPH, L.I., Energy options: changing views from India (1-054)
RULE, T.T., See O'DONNELL, D.T. (3-139)
RUP, R., Experimental investigations of a physical system capable of using solar energy (9-519)
RYBAKOVA, L.E., See AGADZHANOV, V.P. (5-330)

S

SACHDEVA, R.C., See KUMAR, K.L. (3-183)
SADEKAR, G.K., See SUKHATME, S.P. (3-146)
SAHA, H., Electrochemical storage of photovoltaic solar energy (5-356)
SAHAI, V., Continuous steady state biosynthesis of cellulase by *T. viride* QM9414 under controlled pH (4-256)
SAKAI Y., See YOSHIKAWA A. (8-436)
SAKAMOTO R., See KAMIMOTO M. (8-483)
SAKSENA, R.K., Solar collector for rural use (5-317)
  See KEDIA, Y.P. (4-206)
SAKUTA K., Elementary properties of a reverse flat plate type solar heat collector developed for collecting total insolation (8-445)
  Heat-collecting characteristics of reverse flat plate type solar heat collectors (9-527)
  See KAMIMOTO M. (8-483)
  See TANAKA T. (3-189)
SALLES, Y., See LAUVRAYA, H. (8-438)
SALYER, I.O., See WHITAKER, R.B. (5-358)
SAMPSON, W.J., See ILES, P.A. (9-514)
SAMUEL, A.A., Experimental and theoretical investigations of an east-west oriented parabolic concentrator (4-209)
SANCHEZ, S., See MARTINEZ, A.M. (10-579)
SANDERSON, R.W., See O'DONNELL, D.T. (3-139)
SANTANDER, F., See MARTINEZ, A.M. (10-579)
SARAVIA, L., See MANGUSSI, J. (5-325)
SARBOLOUKI, M.M., Chemicals from biomass - the U.S. prospects for the turn of the century (4-252)
SARTI, D., Transformation of solar radiation by fluorescence: application to the encapsulation of cells (10-601)
SASSE, W.H.F., Organic molecular energy storage reactions (2-112)
SASTRI, M.V.C., See NAGASUBRAMANIAN, G. (5-298)
SASTROAMIDJOJO, M.S.A., Introducing solar powered solvent extraction of coconut oil in Panjang Rejo, a village in central Java, Indonesia (2-088)
SATHE, A.P., See GUPTA, K.C. (1-009)
SAUCEDO, E., See CHAMBOULEYRON, I. (4-223)
SAWADA S., See SAKUTA K. (8-445, 9-527)
SAWATA S., See TANAKA T. (3-189)
SAXENA, P.K., See PILLAI, P.K.C. (2-067)
SAYIGH, A.A.M., Greenhouses in hot climate (6-398)
  Solar-based agricultural systems for the Middle East (4-243)
  Technology of flat plate collectors (8-444)
SBERVEGLIERI, G., See ROMEO, N. (2-076)
SCHELLENBACH, S., Methane on the move. A discussion of small anaerobic digesters. Final report (5-347)
SCHMIDT, W.L., See BRAGG, G.M. (3-187)
SCHOOLEY, F.A., See MENDEL, D.A. (2-101)
SCHREITMULLER, K., See LEHNER, G. (3-125)
SCHUBERT, K., Solar sea water desalination for Arab countries (4-240)
SEALOCK, JR., L.J., See MITCHELL, D.H. (10-622)
SEIDENSTICKER, R.G., See DUNCAN, C.S. (8-440)
SEMANA, J.A., See BAWAGAN, P.V. (10-626)
SEN, P., Photovoltaic characteristics of chemically deposited photosensitive cells (1-015)
SENGUPTA, S., See SOHA, H. (4-217)
SERVIDORI, M., See ZIGNANI, F. (6-380)
SESHADRI, C.V., Energy plantation for coromandel littoral (2-100)
  Self-reliant development - an IFIAS sponsored study (4-200)
SEXTON, F.W., See GARNER, C.M. (10-595)
SEYITKURBANOV, S., Effect of closed forced circulation of a steam-air mixture in a solar desalination unit (1-032)
SHA, W.T., See LIN, Z.I.H. (10-618)
SHADYEV, O., Solar water heater with hemicylindrical boiler (1-023)
SHAH, F.H., See QADEER, M.A. (3-164)
SHAKOW, D., Energy and development: the case of Kenya (10-576)
SHANAHAN, Y.J., See JOSEPH, S. (8-471)
SHANKAR, P.N., Development of vertical axis wind turbines (2-107)
SHAO TINGJIE, See LIU KEXIN (3-180)
SHARAN, S.G., See SHARON, M. (9-505)
SHARMA, A.K., Optical and electrical investigations on annealed indium oxide selective coatings produced by spray pyrolysis (3-128)
  See GADGIL, S.B. (10-587)
SHARMA, G.K., See SHINDE, A.S. (4-235)
SHARMA, M.P., A low lift solar water pump (3-145)
SHARMA, S.P., See MISHRA, C.B. (9-522)
SHARMA, V.C., A comparison of thermal performance of austenitic stainless steel solar absorber plates coloured by chemical and thermal oxidation techniques (9-503)
  Direct energy conversion: an attractive option for developing countries (6-377)
SHARON, M., *Saur vidyut kosh*: the solar cell (9-505)
SHARPE, M.H., See ROBERTS, M.L. (10-589)
SHAW, A., Solar drying potatoes (5-328)
SHEARER, W., See DASILVA, E.J. (1-003)
SHELEF, G., See ROUSSEAR, I. (8-475)
SHELPUK, B., Proceedings of the desiccant cooling conference (8-461)
SHEPHERD, D.G., Wind power (5-349)
SHIAN,SU-TE, The construction of simple biogas digesters in the province of Szechwan, China (9-551)
SHIMIZU S., See EZAWA N. (10-612)
SHINDE, A.S., Performance of a honeycomb type flat-plate collector with serpentine tube (4-235)
SHIRAHATA K., See YOSHIDA S. (10-594)
SHIRKIE, R., Fuelling controversy (8-486)
SHORT, T.H., Implementation of a solar pond greenhouse heating system (4-246)
SHOZAWA H., Status of ethanol fuel supply from energy farming (9-544)
SHWARTS, I., See GROSSMAN, G. (4-231)
SIEVERS, D.M., See FISCHER, J.R. (4-264)
SIGALOV, Y.M., See KORYAGIN, N.I. (5-313)
SILVESTRE, R., See DEB HOVEL, F. (10-628)
SIMMONS, H., See COLLARES-PEREIRA, M. (1-022)
SIMPSON, M.H., Demonstration of anaerobic biogas digesters in developing countries. Part III. The Philippines (5-343)
SIMPSON, W.T., See TSCHERNITZ, J.A. (5-322)
SINGH, D., See GUPTA, Y.P. (4-284)
SINGH, G., See RAJPUT, R.K. (2-094)
  See SHARMA, M.P. (3-145)
SINGH, H.J., See RASTOGI, R.P. (1-048)
SINGH, P., See MANNAN, K.D. (4-207)
SINGH, R., See GENIS, A.P. (6-381)
  Review of conductor-insulator-semiconductor (CIS) solar cells (5-302)

SINGH, S.N., Effect of abrasive jet machining (AJM) the edge on the performance of a polycrystalline silicon solar cell (9-515)
  New technique for fabrication of pnn polycrystalline silicon solar cells by simultaneous diffusion of boron and phosphorous into silicon (8-439)
SINHA, A., Effect of heavy doping on the properties of high-low junction (3-141)
SINHA, A.P.B., See POTDAR, H.S. (6-373)
SINNASSE, C., See BRODIN, J. (3-152)
SIVAPAN, S., Direction-independent, concentration-augmented slow-running wind-rotor (10-633)
SIVASEGARAM, S., See VINAYAGALINGAM, T. (3-186)
  See SIVAPAN, S. (10-633)
SKINNER, W.A., Production of cellulase by a thermophilic Thielavia terrestris (3-171)
SKIRSTIMONSKII, A.I., See KOSHEL, M.I. (3-177)
SKRINDE, R.T., Engineering feasibility of fuels from biomass utilizing dairy farm residue (3-179)
SMITH, I.E., See BELL, M.A. (4-274)
SMITH, O.J.M., See SMITH, P.S. (10-634)
SMITH, P.A., See GENIS, A.P. (6-381)
SMITH, P.S., Rimmed polyblade wind turbine (10-634)
SMITH, W., See HARPER, J.P. (6-400)
SODHA, M.S., Performance of an inexpensive constant flow solar collector/storage system in ground (4-236)
  Simple multiple wick solar still: analysis and performance (9-534)
SOFER, S.S., See BRULE, M.R. (9-553)
SOGO T., See YOSHIDA S. (10-594)
SOHA, H., Studies on the improvement of performance of sintered Cu$_2$S/CdS solar cells (4-217)
SOIN, S.S., See RAO, K.S. (9-489)
SOMASHEKAR, H.I., See RAVINDRANATH, N.H. (10-577)
SONOBE M., See USAMI A. (2-078)
SOO, S.L., See LIN, Z.I.H. (10-618)
SOOTHA, G.D., See NAGAR, V.K. (8-428)
SOW, G., See BARLAUD, M. (1-018)
SPILIMAN, C.K., See ROBBINS, F.V. (3-156)
SRIKANTA, S., See NAND, K. (3-169)
SRIRAMULU, V., See GANDHIDASAN, P. (9-525)
  See SAMUEL, A.A. (4-209)
SRIVASTAVA, A., See KUMAR, A. (3-148)
  See SODHA, M.S. (4-236)
  See TIWARI, G.N. (1-028)
STEIN, C., See COLLARES-PEREIRA, M. (1-022)
STEIN, G., Photochemical conversion and storage of solar energy (1-052)
STEPHAN, B., A dome-biogas plant with separate gas holder - a system under experiment in China (4-262)
STERNER, R., See MURO, S. (2-089)
STEWARD, J., Biogas for Javanese villages: the products of digestion (4-265)
STEWART, D.J., Economics of production of biogas from specifically-grown plant material (9-572)
STIRN, R.J., High-efficiency thin-film GaAs solar cells (9-510)
STORTI, G., See LINDMAYER, J. (5-306)
STOUT, B.A., Energy for world agriculture (2-057)
SUBRAMANI, V., See SESHADRI, C.V. (4-200)
SUBRAMANIAN, S.K., See BARNETT, A. (6-403)
SUI LIN, The thermodynamic cycle of the minto solar wheel (9-531)
SUKHATME, S.P., Development and testing of an ammonia-water absorption refrigeration system for a cold storage unit using solar energy (3-146)
SUMITOMO T., Fundamental study on solar brazing (9-533)
  See HAMASAKI M. (10-620)
SUN GOUCHAO, See LIU KEXIN (3-180)
SUNDARAM, P., See GOVINDA RAJU, S.P. (9-562)
SURYANARAYANA, C.V., See CHOCKALINGAM, M.J. (3-140)
SUZUKI T., Electrical properties of Zn$^+$-doped (AlGa)As prepared by molecular beam epitaxy and its use in shallow junction solar cells (8-434)
SVENDSEN, S., See FURBO, S. (4-275)
SVENSSON, P., Survey of existing solar powered refrigeration systems for storage of food stuffs and a method of calculation for a solar powered platen-munters system (6-389)
SVIHEL, B.T., See KORR, A.L. (10-609)
SWAIDAN, B.E., Solar desalination (4-242)
SWARUP, G., Concentrators for solar energy utilization (9-498)
SWISS, M., Energy alternatives for the year 2000 (2-060)
SZEGO, G.C., Design, operation, and economics of the energy plantation as an alternate source of fuels (1-043)
SZOSTAK, J., Zeolites: clay silicates that offer hope of compact solar storage (4-273)

T

TABAROV, T.S., See ALFEROV, Z.I. (1-013)
TABOR, H., Non-convecting solar ponds (8-459)
  Selective surfaces (6-372)
  Solar ponds (non-convective) (9-532)
TADZHIBAEV, F.M., See ALFEROV, Z.I. (1-013)
TAKAHASHI K., See SUZUKI T. (8-434)
TAKAKURA H., Low-cost high-efficiency SnO$_2$/n$^+$-p Si heteroface solar cell (4-218)
TAKEMURA, M., International cooperation with developing countries (10-584)
TAKINAMI K., See TANAKA T. (3-172)
TAMILARASAN, R., Photovoltaic conversion by macromolecular thionine films (8-432)
TANABE I., See TATSUMI T. (3-173)
TANAKA H., See See HAGA K. (5-345)
TANAKA K., Methane production by microorganisms (9-555)
  See WATANABE K. (6-396)
TANAKA S., Experiments on flow-down type solar heat collector (9-521)
TANAKA T., Fundamental studies on heat storage of solar energy (3-189)
  Saccharification of cellulose by acetolysis (3-172)
  See EZAWA N. (10-612)
  See SAKUTA K. (8-445, 9-527)
TANI T., See SAKUTA K. (8-445, 9-527)
  See TANAKA T. (3-189)
TATSUMI, T., Alcohol production from algal starch (3-173)
TCHERNEV, D.I., Solar refrigeration utilizing zeolites (3-162)
TEJERINA, F., See RIERA, J. (3-157)
TENA, F., See RIERA, J. (3-157)
TEWARI, S.K., An evaluation of the strategy of low-cost horizontal-axis windmills (3-195)
THANGARAJ, R., See GADGIL, S.B. (10-587)
THEREZ, F., See ESTEVE, D. (10-599)
THOMAS, R.E., Silicon solar cells. I. Basics (9-507)
  Silicon solar cells. II. Practical aspects (10-597)

THOMAS, S., See SESHADRI, C.V. (4-200)
THORNTON, R.H., See HIGGINSON, B. (9-540)
TI, L., Solar energy research and application in China (4-205)
TILLMAN, D.A., The economic values of wood residues as fuel (1-044)
TINGEY, G.L., See GORDON, N.R. (6-370)
TIWARI, F.K., See GUPTA, B.K. (5-295)
  See GUPTA, K.B. (10-590)
TIWARI, G.N., Analysis and performance of a south facing solar wall (1-028)
  See KUMAR, A. (3-148)
  See SODHA, M.S. (4-236, 9-534)
TIWARI, N.K., See GUPTA, V.K. (1-025)
TOKUYAMA F., See SKINNER, W.A. (3-171)
TOMAR, M.S., See GARCIA, F.J. (9-508)
TORMA, A.E., See HOMHUAL, C. (6-371)
TORRES, C., See CHEEMA, L.S. (4-283)
TRINDADE, S.C., See CARVALHO, A.V. (4-254)
TRIPATHI, T.C., See NAGAR, V.K. (8-428)
TROTTER, W.K., Solar energy for agriculture: review of research (10-586)
TSCHERNITZ, J.A., Solar-heating, forced-air, lumber dryer for tropical latitudes (5-322)
TSUJI T., The development of photovoltaic conversion systems with sunlight concentration (5-308)
TURNACLIFF, W., See SCHELLENBACH, S. (5-347)
TURNER, G.W., High-efficiency InP homojunction solar cells (10-593)
TVARDOCHLIEB, E., See MURGU, Z. (1-037)
TYAGI, H.R., See GUPTA, V.K. (1-025)
TYAGI, R.C., See SODHA, M.S. (9-534)

U

UCHIJIMA J., Natural energy sources and agriculture (3-121)
UEDA S., Alcoholic fermentation of raw starch without cooking by using black-koji amylase (10-625)
UGARTE, J., See MURO, S. (2-089)
UMAROV, G.Y., Low-temperature thermal solar motor (2-084)
USAMI A., The development of a high-efficiency silicon BSF type solar cell (2-078)
USHAKOVA, A.D., See AGADZHANOV, V.P. (5-330)
USHIYAMA I., Basic study of methane fermentation (6-405)

V

VAIDYA, V.H., See HARKARE, W.P. (4-269)
VALVERDE, S., See MARTINEZ, A.M. (10-579)
VAN ANDEL, J.G., See COHEN, A. (2-103)
VAN BUREN, E.A., The Chinese development of biogas and its applicability to East Africa (3-175)
VAN DER LEIJ, M., Possibility of black zinc oxide as spectrally selective coating for low temperature solar collectors (3-129)
VANDER PLAS, H.A., See JAMES, L.W. (6-382)
VAN DEURSEN, A., See COHEN, A. (2-103)
VAN HOOK, R.I., Environmental effects of harvesting forests for energy (10-639)
VANHOUTTE, G., Survey of semiconductor combinations for optimum heterojunction thin film solar cells (5-307)
VAN VUI PHAM, See BRODIN, J. (3-152)
VARANI, F., See SCHELLENBACH, S. (5-347)
VAREL, V.H., See HASHIMOTO, A.G. (9-557)
VASEASHTA, A.K., Determination of the minority carrier diffusion length in silicon solar cells (4-224)
VASU, I., See RAO, M.R. (5-296)
VASUDEVARAJU, V.A., See GUPTA, C.L. (6-364)
VATANSEVER, A., Greenhouses oriented to the sun (for more and early production) (1-036)
  Heating of the solar orientated greenhouse by means of solar air heater and solar pond and the procurement of the greenhouse humidity through special film (10-604)
VAUGHAN, B.D., A simple solar cooker from India (3-159)
VENKATARAMANI, G., See SESHADRI, C.V. (2-100, 4-200)
VENKATESH, A., Experimental investigation of an intermittent ammonia-water solar refrigerator (10-605)
  Performance of an intermittent ammonia-water solar refrigerator operating with a flat plate collector (5-320)
VENKATESWARLU, U., Program and progress of DST sponsored solar photovoltaic work in India (5-304)
VERGARA, W., Fuels from biomass. Comparative study of the potential in five countries: the United States, Brazil, India, Sudan, and Sweden (3-163)
VERMA, S.D., Vertical axis windmill and wind collector (5-350)
VIALARET, G., See ESTEVE, D. (10-599)
VIGIL, O., See ROMEO, N. (2-076)
VILLA, L.G., Natural and convected air drying of cassava chips (8-456)
VINAYAGALINGAM, T., Variable-stroke, wind-operated water-pumping system (3-186)
VINCENT, G.W., Luminescent solar concentrator (LSC): a diffuse sunlight concentrator for solar cells (10-602)
VIRINA, E.S., Improved cooking stove (6-402)
VOJDANI, S., Research in photovoltaic cells (1-016)
  Solar energy R & D in Iran: the approach and the philosophy (5-291)
VOLESKY, B., Anaerobic digestion-optimization of energy source from wastes (2-102)
VON HATTEN, P.P., See ROMAK, R.K. (4-278)
VON KONIG, F., How one builds windmills. Calculation construction and operation (4-267)
VULETIN, J., See KULISIC, P. (10-638)
VYAS, D.L., See KALLA, J.C. (8-468)

W

WAKE, L.V., See HILLEN, L.W. (8-465)
WALKER, E.H., See KORR, A.L. (10-609)
WALTER, H., See BURGESS, E.L. (3-142)
WALTON, JR., J.D., Solar energy for rural development in Asia and Pacific Region (1-004)
WALTON, L.R., Storing solar energy in an underground rock bed (10-635)
WANG XIYI, See LIANG SHAOXIAN (5-309)
WARD, R.F., Alcohols as fuels - the global picture (9-543)
WARNER, G.L., See LANE, G.A. (3-194)
WARREN, D.R., See HILLEN, L.W. (8-465)
WATANABE K., Basic study on inclined wick-type solar stills (6-396)
WEBER, E.R., Photovoltaics and environmental impact considerations (3-196)
WEBER, S.L., See MITCHELL, D.H. (10-622)

WEINER, D., See SHAKOW, D. (10-576)
WEINGART, J.M., Global aspects of sunlight as a major energy source (2-061)
WEST, D.W., See VAN HOOK, R.I. (10-639)
WESTBERG, J.E., See ADWALLADER, E.A. (9-564)
WESTERTERP, K.R., See GROENEVELD, M.J. (2-116, 10-642)
WETTERMARK, G., Storage of low temperature heat: solar energy thermal storage (2-111)
WHARTON, L., See COLLARES-PEREIRA, M. (1-022)
WHITAKER, R.B., Energy storage for solar air conditioning applications utilizing a form-stable, high density polyethylene pellet bed (5-358)
WHITE, D.H., See WOLFE, D. (9-495)
WIHL, M., High efficiency, high density terrestrial solar panels (1-017)
WILBUR, P.J., See MEREDITH, D.B. (5-321)
WILCOX, K., See DAVIDSON, M. (3-197)
WILKE, C.R., Process development studies on the bioconversion of cellulose and production of ethanol (8-470)
WILKINS, E.S., Model stratified layer solar pond with enhanced heat storage (2-092)
WILLIAMS, A., Methane digesters in remote rural areas (3-176)
WILLIAMS, L.A., Solar bioconversion systems based on algal glycerol production (4-255)
WILLIAMSON, W.R., See ADWALLADER, E.A. (9-564)
WILLMER, A.C., The aerodynamic design and testing of a vertical axis windmill (5-351)
WILSON, D.C., See BELLANDE, R.H. (6-397)
WINDAWI, H.M., Inexpensive portable Cu$_2$S - CdS radiometer (5-301)
WINGET, R.R., American Indian projects in solar energy: community involvement (8-425)
WINKLER, J.P., Solar energy in theory and practice (5-292)
WINSBERG, S., Solar perspectives: new world Brazil, energy leader (3-118)
WINSTON, R., Fundamentals and techniques of nonimaging optics for solar energy concentration. Final report (10-591)
  See COLLARES-PEREIRA, M. (1-022)
  See RABL, A. (2-070, 4-233)
WINSTROM-OLESEN, B., See HOLDON, R.S. (1-046)
WITTENBERG, L.J., Performance of a large, salt-gradient solar pond (8-458)
WITTWER, V., See GOETZBERGER, A. (10-600)
WOHLGEMUTH, J., See WIHL, M. (1-017)
WOHLGEMUTH, J.H., Nonreflecting vertical junction silicon solar optimization (4-220)
WOLF, D., See KUDISH, A.I. (1-020)
WOLFE, D., Solar energy experience in Israel: a case study (9-495)
WOLFF, G., See KAMATH, S. (8-435)
WONG, A., See MARTINEZ, A.M. (10-579)
WOODALL, J.M., See CUOMO, J.J. (5-294)
WOOLLAM, V.J., See VOJDANI, S. (5-291)
WRIGHT, D., Architecture au naturel (8-426)
WRINGLEY, C.V., See LINDMAYER, J. (5-306)
WRINGLEY, C.Y., See WOHLGEMUTH, J.H. (4-220)
WU SUICHENG, See LIANG SHAOXIAN (5-309)

X

XIAO JIANQIU, See XU SHAOMO (2-095)
XU JIEGUAN, See LIU KEXIN (3-180)
XU SHAOMO, Concave mirror solar cooker part I (2-095)

Y

YAKOBOV, Y.N., See SHADYEV, O. (1-023)
YAMAGUCHI K., CdS-CdTe solar cell prepared by vapor phase epitaxy (1-014)
YAMANAKA S., See TANAKA T. (3-172)
YANG, P.Y., Enhanced energy production and water reuse for swine operation in Hawaii (8-476)
YANG, V., See CARVALHO, A.V. (4-254)
YARDI, N.R., See PANDYA, U.K. (5-319)
YATSYUK, M.V., See KOSHEL, M.I. (3-177)
YELLOTT, J.I., Passive solar progress (9-537)
YOSHIDA K., See OKUBO H. (4-210)
YOSHIDA S., Antireflection coatings on metals for selective solar absorbers (6-374)
  High efficiency Al$_x$Ga$_{1-x}$As-GaAs solar cells with high open-circuit voltage and high fill factor (10-594)
  Selective transparent filters produced by optical multilayer coatings (10-588)
YOSHII F., See OKUBO H. (4-210)
YOSHIKAWA A., High efficiency n-CdS/p-InP solar cells prepared by the close-spaced technique (8-436)
  Study on junction properties of n-CdS/p-InP heterodiodes by using injection electroluminescence (6-378)
YOSHINO A., Economic analysis of ethanol production by fermentation (10-640)

Z

ZADIRANOV, Y.M., See ALFEROV, Z.I. (1-013)
ZANGRANDO, F., A simple method to establish salt gradient solar ponds (5-326)
ZANOTTI, L., See ROMEO, N. (2-076)
ZEIMETZ, K.A., Growing energy: land for biomass farms. Agricultural economic report (Final) (4-253)
ZHANG RUIFENG, The test and use of thin film CdS solar cells under different load conditions (5-310)
ZHURAEV, T.O., See ACHILOV, B.M. (3-158)
ZIGNANI, F., Study of ion implanted n$^+$ layers for silicon solar cells (6-380)
ZIMMER, P.B., See LIN, R.J.H. (9-501)
ZINKO, H., See HEDMAN, H. (5-355)
ZITEK, W., Preliminary results from a test array of 3X CPC collectors in a school heating application (3-154)
  See COLLARES-PEREIRA, M. (1-022)
ZOETEMEYER, R.J., See COHEN, A. (2-103)

SELECTED ARTICLE LIST

Issue No.		
1	C. R. Das and Sudhir D. Ghatnekar	Replacement of cowdung by fermentation of aquatic and terrestrial plants for use as fuel, fertilizer and biogas plant feed
2	S. Kakaç and Y. Yener	Storage of solar energy
3	Mài Xīnshèng, Chén Rǔchen, Lǐ Niàn-guó, Hú Chéngchùn and Walter Shearer	The Xinbu System: an integrated rural production system
4	R. Winston and J. O'Gallagher	Non-imaging concentrators for solar thermal energy
5	E. Fanetti, C. Flores, G. Guarini, F. Paletta and D. Passoni	High efficiency 1.43 and 1.69 eV band gap $Ga_{1-x}Al_xAs$-GaAs solar cells for multicolour applications
6	D. O. Hall	Renewable resources (hydrocarbons)
8	V. Geethaguru	Poghil
9	Soedjatmoko	Energy, culture and history

SPECIAL CONFERENCE ISSUE - LIST OF ARTICLES

7	C. Ian Jackson	The Conference: background and prospects
	D. D. C. Don Nanjira	Conditions for the success of the Nairobi Conference
	Maurice Strong and Mahbub ul Haq	Renewable energy: policy and options
	S. Schwartz	Energy in the North-South dialogue: a private sector perspective
	A. Agarwal, T. Bartlem and R. T. Hoffmann	Solar energy: twilight or dawn?
	J. H. Malinowski and K. R. Kubitz	Looking towards the future, building on the past: developing new energy sources
	Ignacy Sachs	Energy, food, ecodevelopment
	M. S. Swaminathan	Overcoming barriers to implementing national renewable energy programmes: the case of India
	J. Goldemberg	Overcoming barriers to implementing national renewable energy programmes: the case of Brazil

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

ASSET
The United Nations University
Toho Seimei Building
15-1 Shibuya 2-chome, Shibuya-ku
Tokyo 150, Japan
Tel: (03) 499-2811 Telex: J 25442
Cable: UNATUNIV TOKYO

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